APPLICATION AND TECHNICAL GUIDE

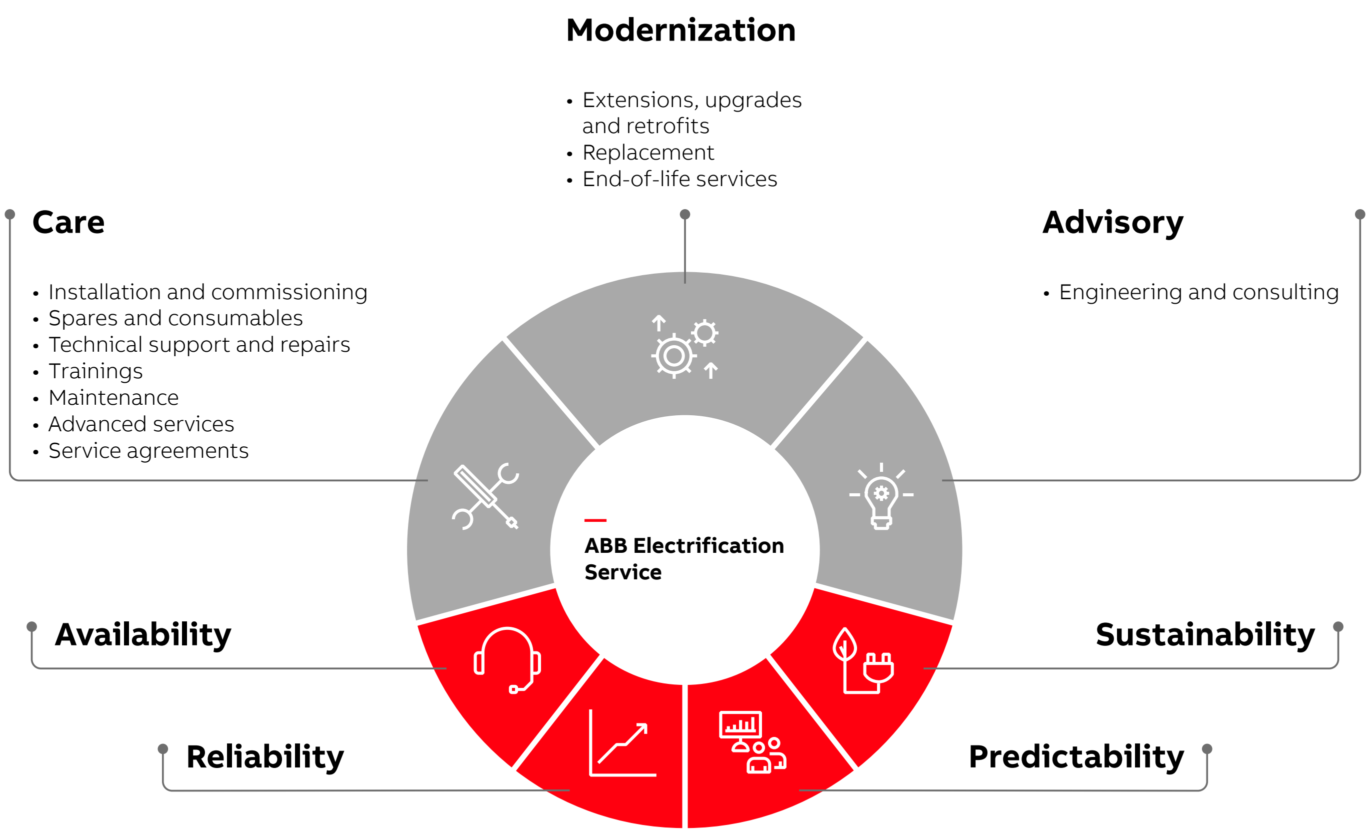
SecoGear 5kV-15kV IEEE Metal Clad Switchgear

GE legacy product
documentation

In 2018 ABB acquired GE Industrial Solutions. SecoGear is now serviced and maintained by ABB. If you need spare parts or your installed equipment has aged and requires modernization or replacement – ABB is your first point of contact (look for contact details on the last page).

ABB provides comprehensive maintenance, diagnostics, and repair services for medium voltage and low voltage electrical apparatus.

The ABB Electrification Service offering is comprised of services that will help you to take care of the equipment, modernize it, and recommend the most appropriate business decisions to guarantee the availability, reliability and sustainability of critical assets and meet your evolving needs.



HAZARD CLASSIFICATIONS

The following important highlighted information appears throughout this document to warn of potential hazards or to call attention to information that clarifies a procedure.

Carefully read all instructions and become familiar with the devices before trying to install, operate, service or maintain this equipment.

⚠ DANGER

Indicates a hazardous situation that, if not avoided, will result in death or serious injury.

⚠ WARNING

Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

CAUTION

Indicates that if the hazard is not avoided could result in minor or moderate injury.

NOTICE

Is used to notify of practices not related to personal injury.

TRADEMARKS

SecoGear®	Seco RMU®
Seco Cube®	SecoBloc®
SecoVac® VB2+	Multilin®

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WARRANTY

This document is based on information available at the time of its publication. While efforts have been made to ensure accuracy, the information contained herein does not cover all details or variations in hardware and software, nor does it provide for every possible contingency in connection with installation, operation, and maintenance. Features may be described herein that are not present in all hardware and software systems.

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No warrantees of merchantability or fitness for purpose shall apply.

Contact your local sales office if further information is required concerning any aspect of SecoGear switchgear and SecoVac VB2+ breaker operation or maintenance.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

SECTION 1. SECOGEAR SWITCHGEAR CONCEPTS AND BASIC CONFIGURATIONS

This *Application Guide* provides information necessary to help plan and specify medium-voltage power system switchgear by utilizing SecoGear Metal-clad switchgear.

This publication can be used to write complete specifications for most switchgear applications. Included is guidance in equipment layout, ratings, relay protection, and references to appropriate standards and literature. Our engineering services, under special contract agreements, will perform power system studies, including the necessary calculations and comparisons.

The first four sections of this guide discuss topics applicable to any type of medium-voltage metal-clad switchgear. Information is provided for circuit breaker ratings and selection, control power requirements, basic circuit protections considerations, and specific recommendations for protection, instrumentation, and control for basic switchgear circuits.

The remaining sections of the application guide explain SecoGear application and specification. The modular construction and the use of multifunction relays and meters are basic to SecoGear and are shown through application details covering the use of SecoGear switchgear and SecoVac breakers in basic circuit applications. Also included are auxiliary unit and power conductor compartment structuring.

After selecting individual units, an optimum lineup configuration can be developed using the guidelines given. A specification procedure, complete with Guide Form Specifications, is recommended to facilitate the documentation of SecoGear Metal-clad switchgear requirements.

Start with your system voltage and current requirements, and work through the guide in a step-by-step fashion. The guide's structure is based on extensive engineering experience and will serve as a checklist to aid in preparing complete specifications.

A brief introduction to SecoGear will serve as a useful starting point to begin the application procedure.

SECOGEAR METAL-CLAD SWITCHGEAR

SecoGear Metal-clad switchgear is designed to house the latest vacuum circuit breaker, SecoVac VB2+, and can be used for applications on 4.76 kV, 8.25 kV, and 15 kV power systems for 31.5 kA and 40 kA. A typical section of SecoGear with a single breaker and rollout compartment is shown in Figure 1-1.

Figure 1-1: Typical SecoGear 2-High Section

SecoGear metal-clad switchgear is designed with a full IEEE metal-clad compartment, bus, and cabling isolation. SecoVac breakers offer the benefits of reliable vacuum interrupters, low maintenance, and reduced breaker size and weight.

Specifically, SecoGear switchgear incorporates the following basic design elements:

- SecoGear provides two-high breaker stacking for application flexibility and floor space savings

- SecoGear utilizes modular construction resulting in one basic vertical section size, simplifying system planning and increasing installation savings
- SecoGear features four-high auxiliary arrangements, providing additional flexibility and use of floor space
- SecoGear allows for intermixing auxiliary and a breaker compartment in the same vertical section

Certain elements in the switchgear application procedure are affected by these fundamental design features. Cubicle stacking, cabling direction, and VT & CPT compartment considerations are key when translating the one-line diagram into a valid arrangement of switchgear cubicles, auxiliary rollouts, and bus connections in a lineup. These application considerations are necessary as a result of the equipment design. A brief illustration of SecoGear switchgear design concepts is provided to assist in understanding.

Figure 1-2: Section Contents

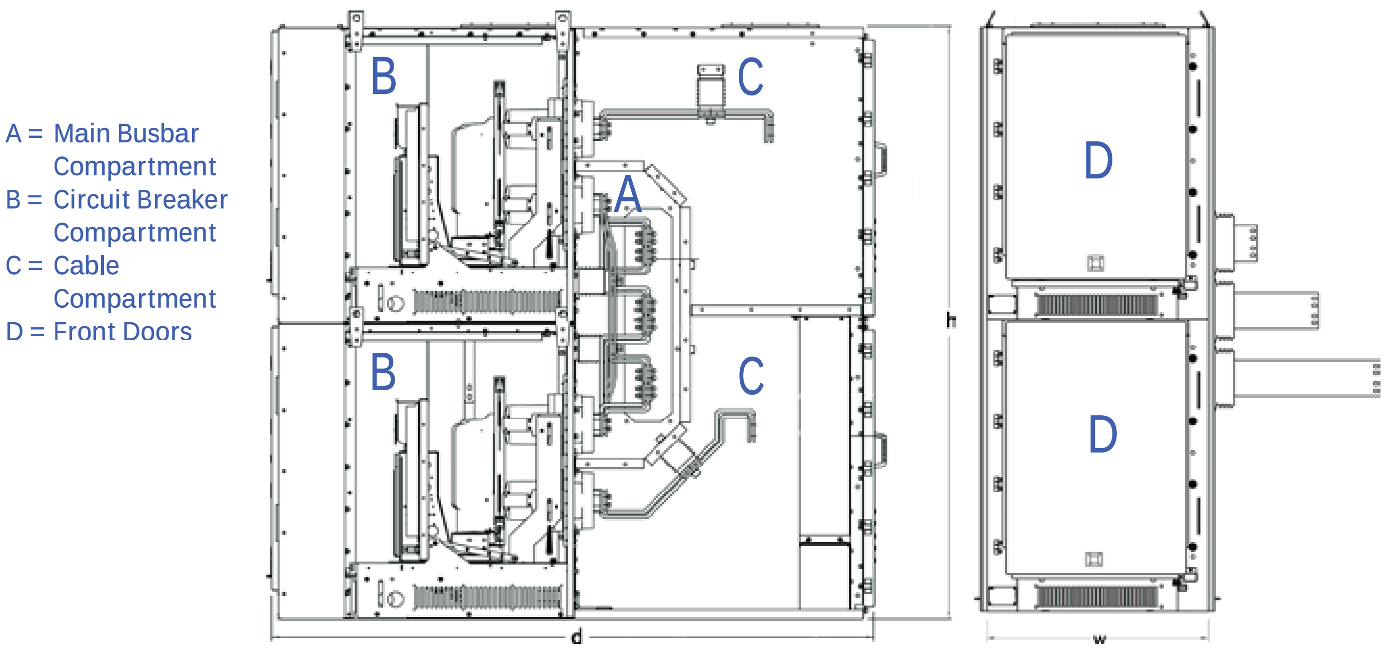


Table 1-1: Typical Dimensions for Indoor Construction

Height (h)	95 in [2413 mm]
Width (w)	36 in [914 mm]
Depth (d)	95.05 in [2414 mm]

Breakers and auxiliary devices can be accommodated in the upper and lower compartments, as shown in Figure 1-3 and Figure 1-4, in a variety of configurations.

Figure 1-3: Typical One-High Breaker

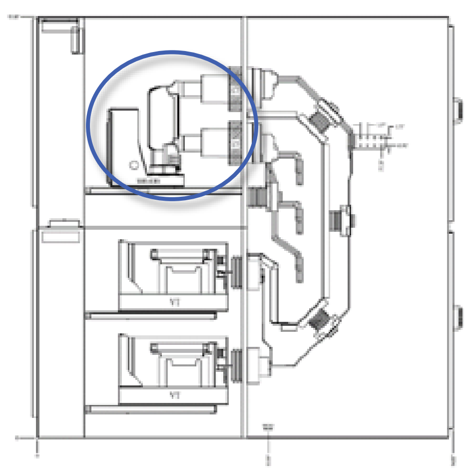
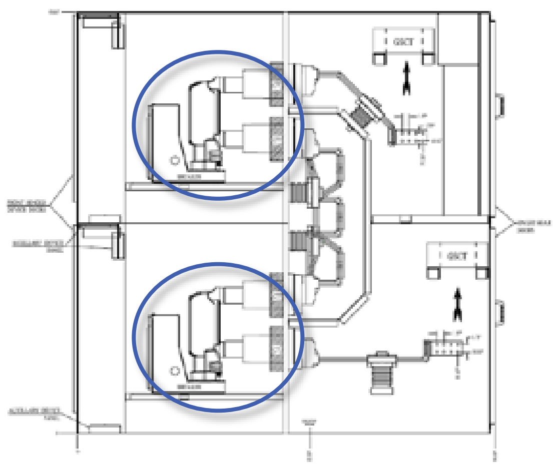


Figure 1-4: Typical Two-High Breakers



SWITCHGEAR STANDARDS

SecoVac VB2+ circuit breakers are rated per IEEE C37.04 and C37.06 standards (Table 1-2). Available ratings are shown in Table 3-1.

SecoGear switchgear is designed, built, and tested to the applicable industry standards shown in Table 1-2 and Table 1-3.

SecoGear equipment is available in NEMA 1 indoor construction. Typical section outlines for each of the basic equipment types, along with dimensions and weights are shown in SECTION 6. "Standard SecoGear Construction, Features, and Installation."

Underwriters Laboratories, Inc. (UL)

SecoGear Metal-clad switchgear and associated circuit breakers are available with the option for UL labeling (File No. E468553). Device selection and options are all considerations when providing a UL label. The requirement for UL labeling must be made known during the bidding stage.

> **NOTICE**
> Not all medium-voltage switchgear assemblies qualify for UL listing.

Service Conditions

SecoGear is designed for the normal service conditions of indoor switchgear per IEEE Standards:

Temperature

- Maximum Ambient: 104 °F [40 °C]
- Minimum Ambient: -22 °F [-30 °C]

Humidity

- Maximum Relative: 95%

Altitude

- Maximum: 3300 ft [1000 m] a.s.l.
- High Altitude: At altitudes above 1000 m, consult IEEEC27.20.2 for derating factors applicable to dielectric and current values

Applicable Industry Standards

Table 1-2: Applicable American National Standards Institute (ANSI) Standards

Standard No.	Description
C37.04	Rating Structure for AC High-Voltage Circuit Breaker IEEE Standard
C37.06	AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities Breakers
C37.09	IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a symmetrical Current Basis Breakers
C37.10	Application Guide for Power Circuit Breakers
C37.11	Power Circuit Breaker Electrical Control Requirements
C37.20.2	Metal-Clad Switchgear Assemblies

Table 1-3: Applicable National Electrical Manufacturers Association (NEMA) Standards

Standard No.	Description
SG-4	Power Circuit Breakers
SG-5	Power Switchgear Assemblies

MODULAR CONSTRUCTION AND TYPICAL SECTIONAL VIEWS

The standard cubicles or modules are shown in Figure 1-5 through Figure 1-8. The basic concepts for two-high unit stacking and options with rollouts are shown in Figure 1-9 and Figure 1-10. Additional illustrations will be provided to assist in the layout of a SecoGear lineup in SECTION 5 "SecoGear Switchgear Applications."

Modular Compartments

VT Rollout and CPT Rollouts can be intermixed in the same compartment. The rollouts are the same physical size and can be either upper or lower drawout tray.

Figure 1-5: Dual VT Rollouts, Line/Bus Connected – Upper or Lower Section

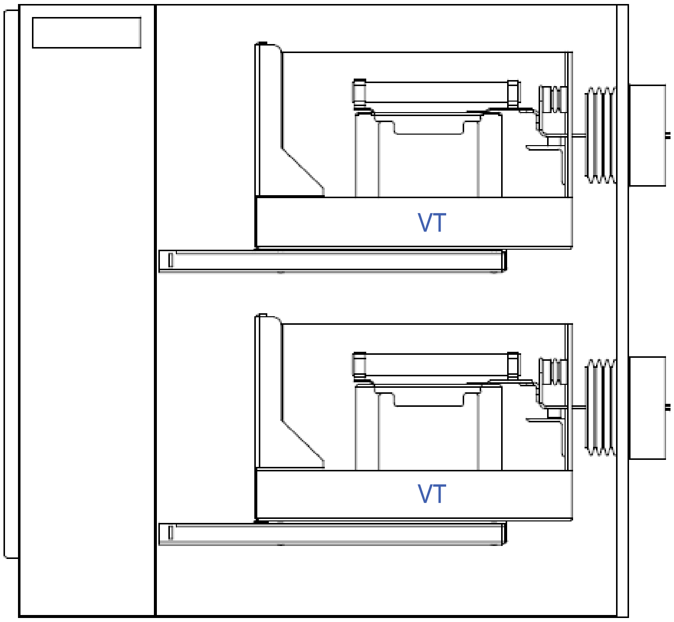


Figure 1-7: 1200 A/2000 A – Upper or Lower Breaker Section

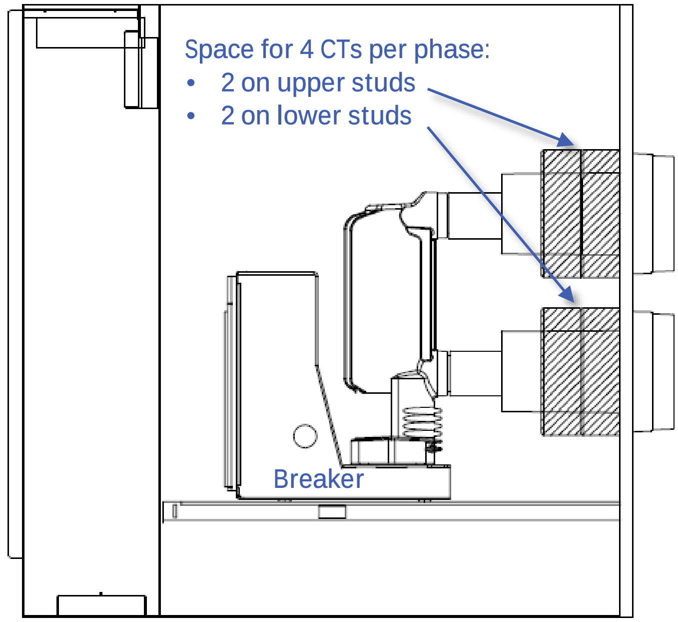


Figure 1-6: Dual CPT Rollouts, Line/Bus Connected – Upper or Lower Section

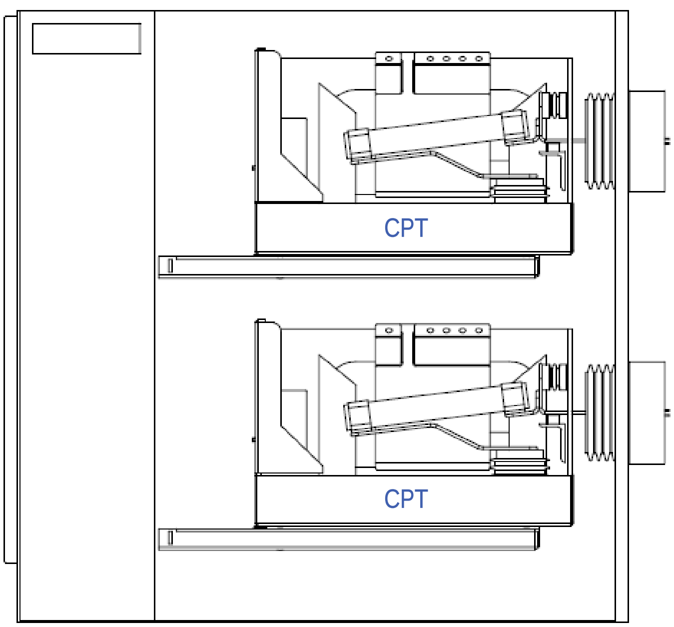
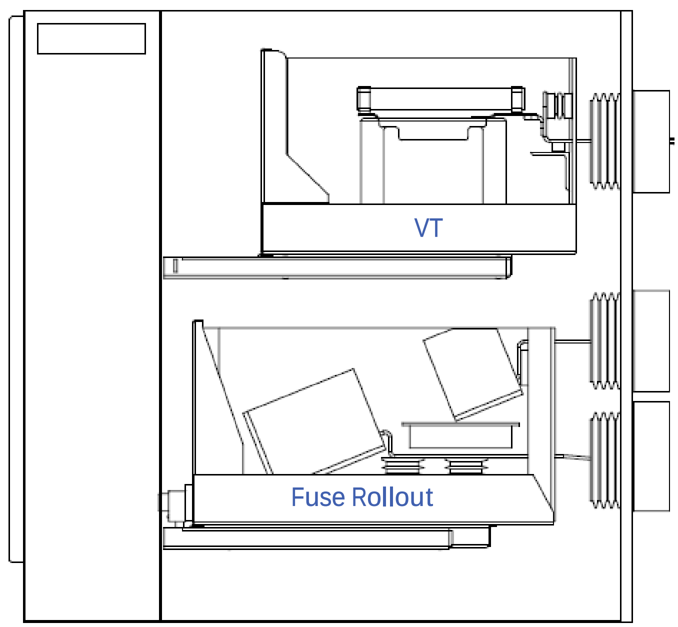


Figure 1-8: VT Rollout, Line/Bus Connected and Fuse Rollout, Line Connected – Lower Section



Rollout Configurations

Figure 1-9: Dual Rollouts

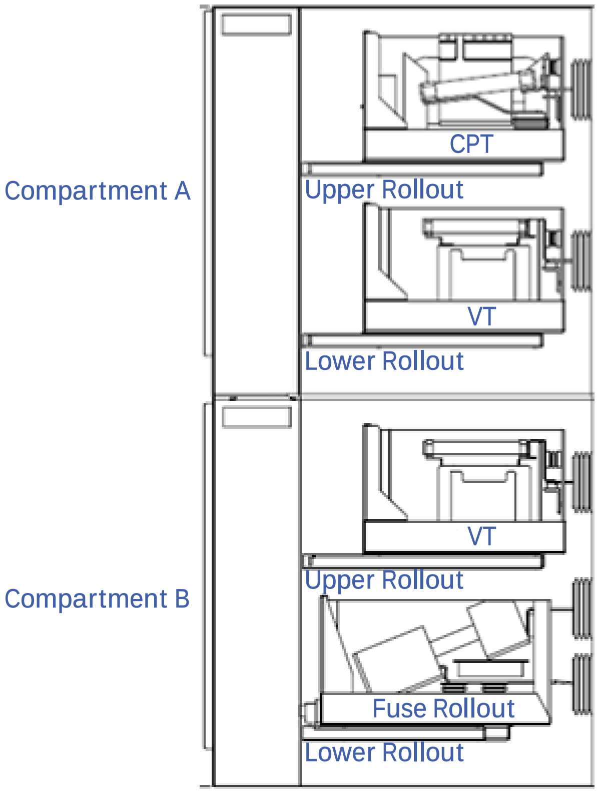


Figure 1-10: Single Rollouts

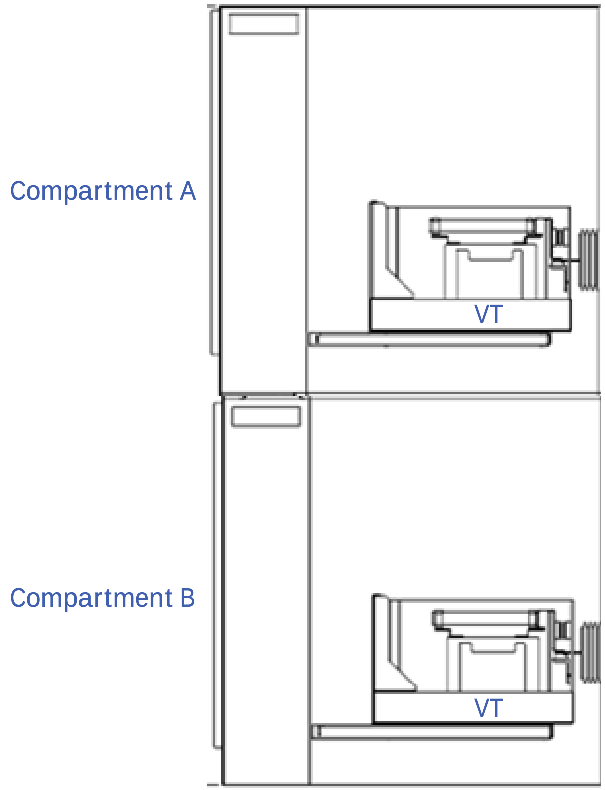


Table 1-4: Permitted Rollout Unit Combinations

Device	Ratings	Compartment A, Single Rollout	Compartment A, Dual Rollouts[4]		Compartment B, Single Rollout	Compartment B, Dual Rollouts[5]	
			Upper	Lower		Upper	Lower
VT Rollout	5 kV – 15 kV	Yes	Yes	Yes	Yes	Yes	Yes
CPT Rollout	5 kVA, 10 kVA, 15 kVA	Yes	Yes	No	Yes	No	Yes
Fuse[1]		Yes[3]	No	No	Yes	No	Yes

Notes:

1. All fuse rollouts are equipped with fuse clips for size C EJ1/EJO1 fuses. Clips can be adjusted for 12" or 15" centers. Fuse rollouts require the installation of a keylock to prevent pulling the drawer out under load.
2. A single rollout in compartment A or B can be located in the upper or lower position, as shown in Figure 1-10.
3. A fused rollout in compartment A is available as bus connected only.
4. The upper rollout in compartment A can be bus connected as long as the lower rollout in compartment A is bus connected. The lower rollout in compartment A can be bus connected, regardless of the connection to the upper rollout in compartment A. The lower rollout in compartment A can be line connected only if the upper rollout in compartment A is also line connected.
5. The lower rollout in compartment B can be bus connected as long as the upper rollout in compartment B is bus connected. The lower rollout in compartment B can be line connected, regardless of the connection to the upper rollout in compartment B. The upper rollout in compartment B can only be line connected if the lower rollout if compartment B is also line connected.

Two-High Breaker and Auxiliary Stacking

SecoGear allows stacking of various modules or compartments into a vertical section. Typical equipment section views in Figure 1-11 through Figure 1-26 illustrate how upper and lower units can be combined with the associated power connections.

Figure 1-11: Breaker in Compartment A, Bus-connected VTs in Compartment B

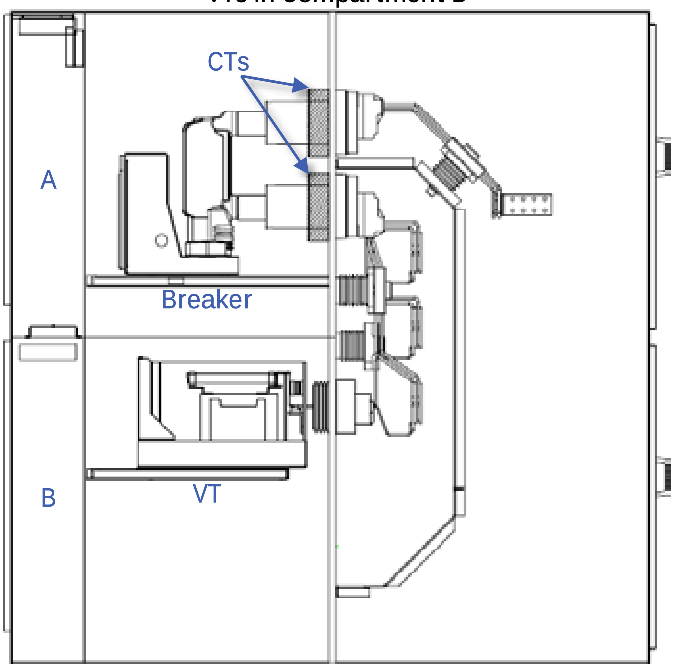


Figure 1-12: Breaker in Compartment A, Line-connected VTs in Compartment B

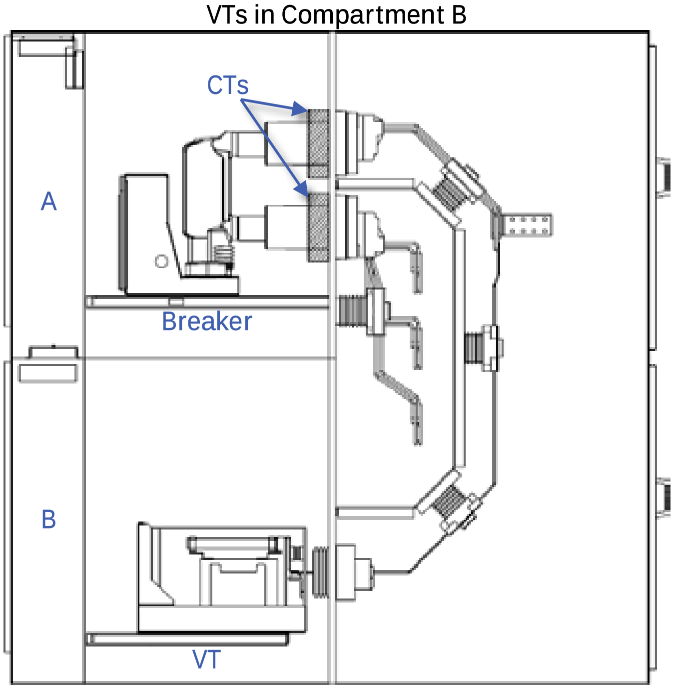
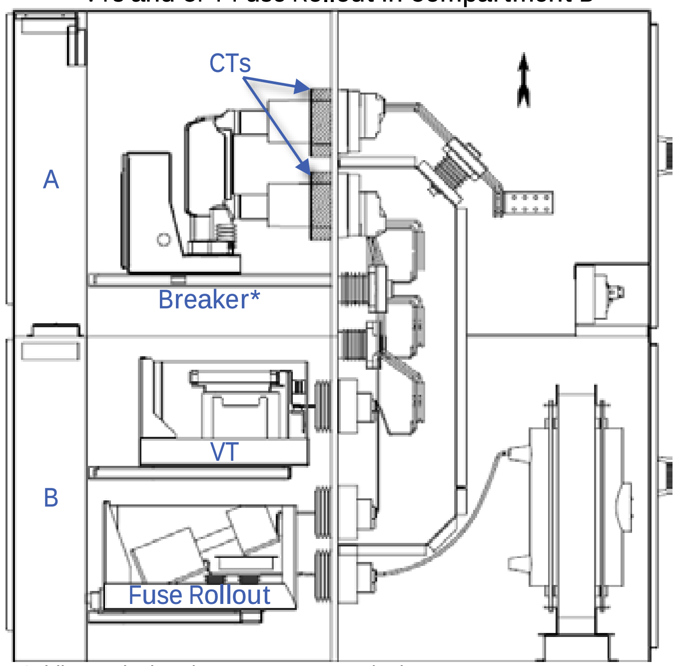


Figure 1-13: Breaker in Compartment A, Bus-connected VTs and CPT Fuse Rollout in Compartment B



* Cabling to the breaker must enter or exit above.

Figure 1-14: Breaker in Compartment A, Line-connected CPT and VT Rollouts in Compartment B

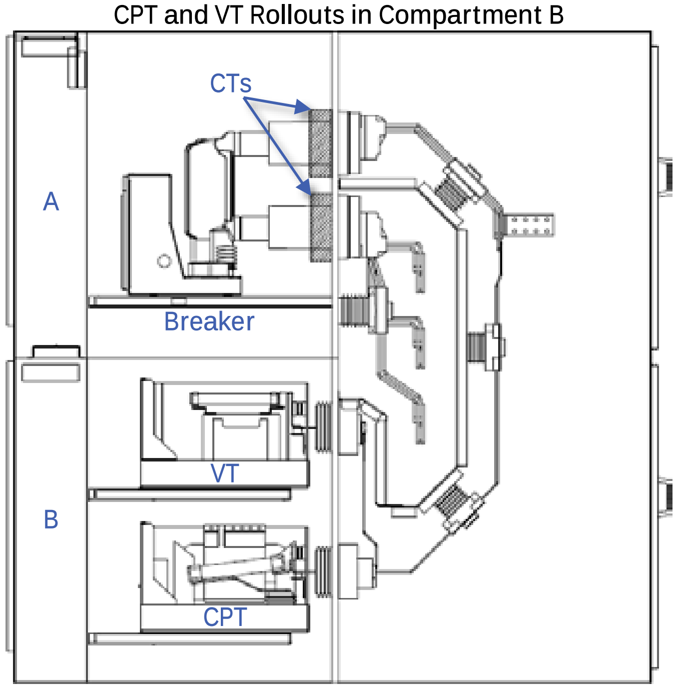


Figure 1-15: Breaker in Compartment A, Line- and Bus-connected VT Rollouts in Compartment B

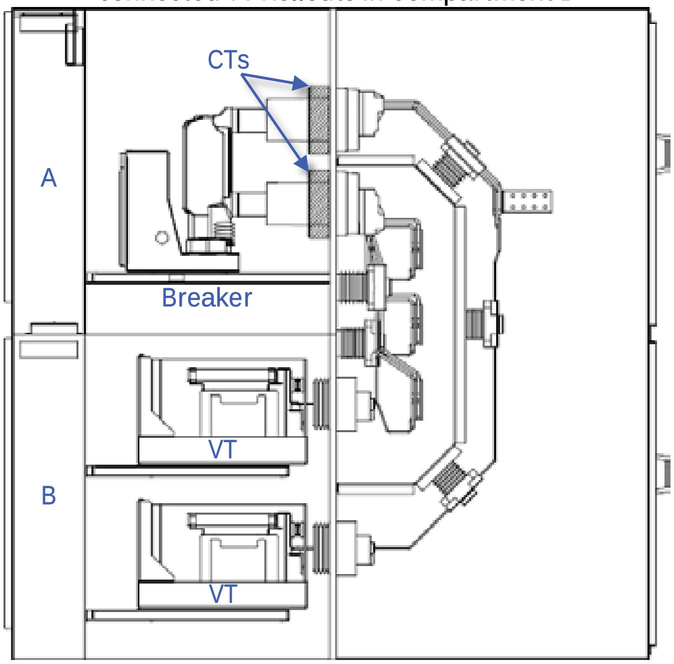


Figure 1-17: Breaker in Compartment B, Bus-connected CPT in Compartment A

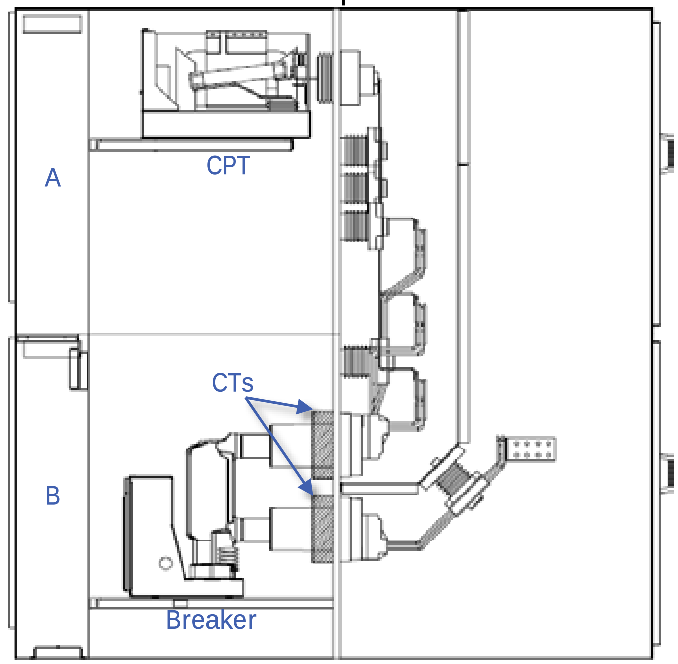


Figure 1-16: Breaker in Compartment B, Bus-connected VT Rollout in Compartment A

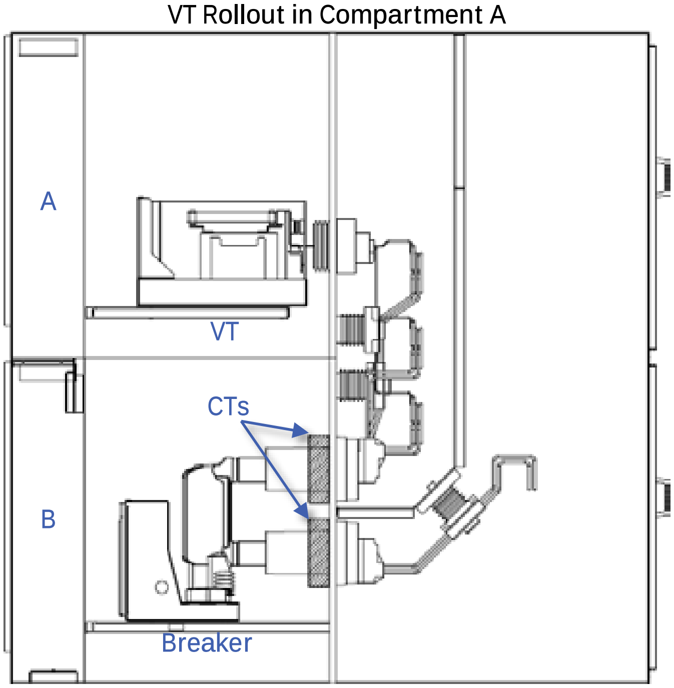


Figure 1-18: Bus Entry in Compartment A – Cabling Above, Breaker in Compartment B – Cabling Below

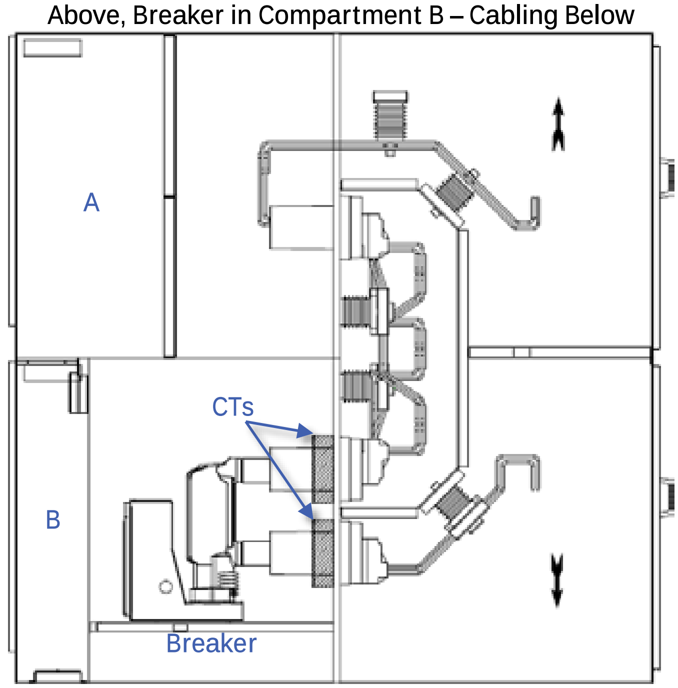


Figure 1-19: Breaker in Compartment B, Bus-connected VTs and CPT in Compartment A

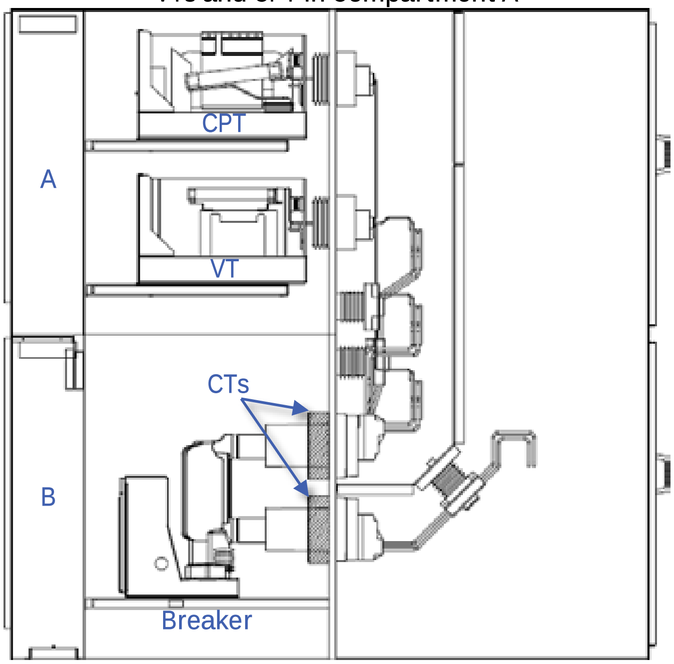


Figure 1-21: Typical Two-high Breaker Section – Cabling Below

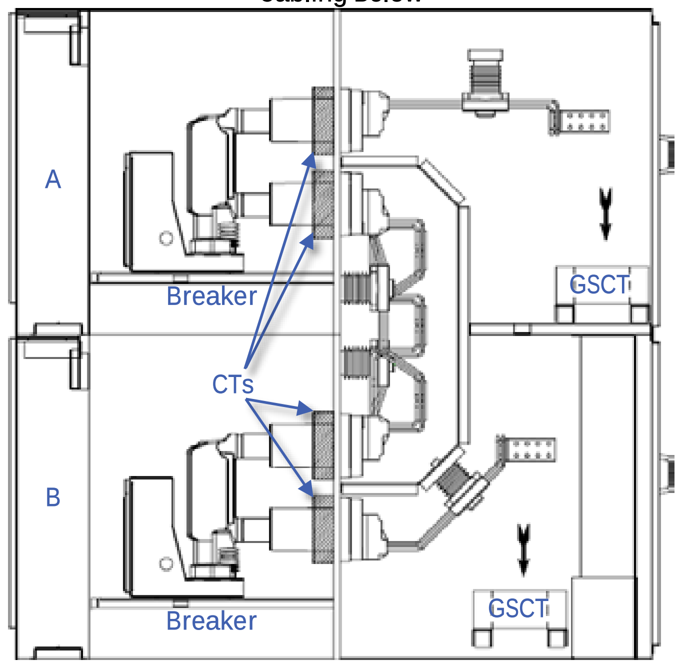


Figure 1-20: Breaker in Compartment B, Line-connected VT Rollouts in Compartment A

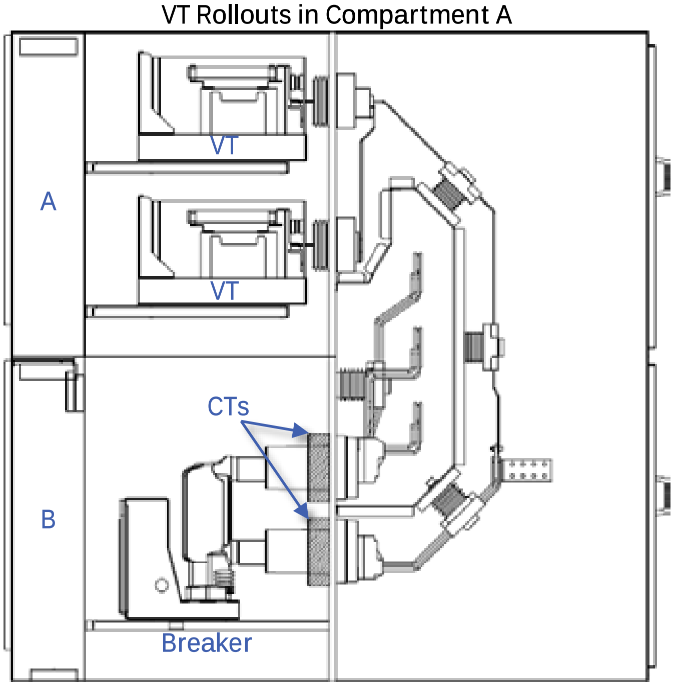


Figure 1-22: Typical Two-high Breaker Section – Cabling Above

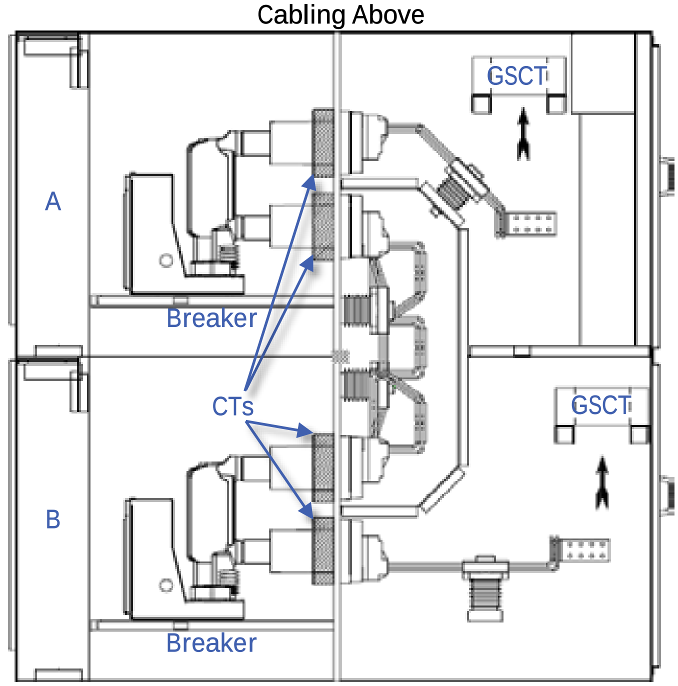


Figure 1-23: Breaker in Compartment A – Cabling Above, Bus Entry in Compartment B – Cabling Below

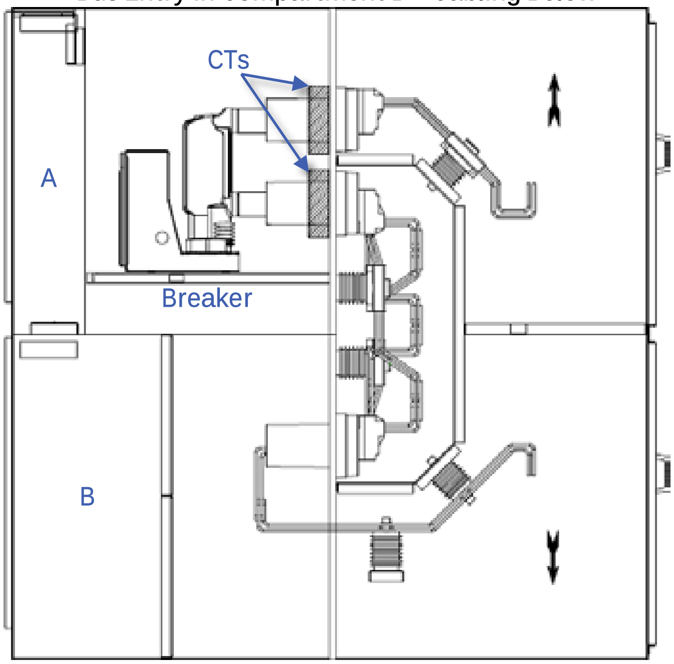


Figure 1-25: Bus-connected VTs in Compartment A, Bus Tie Breaker in Compartment B

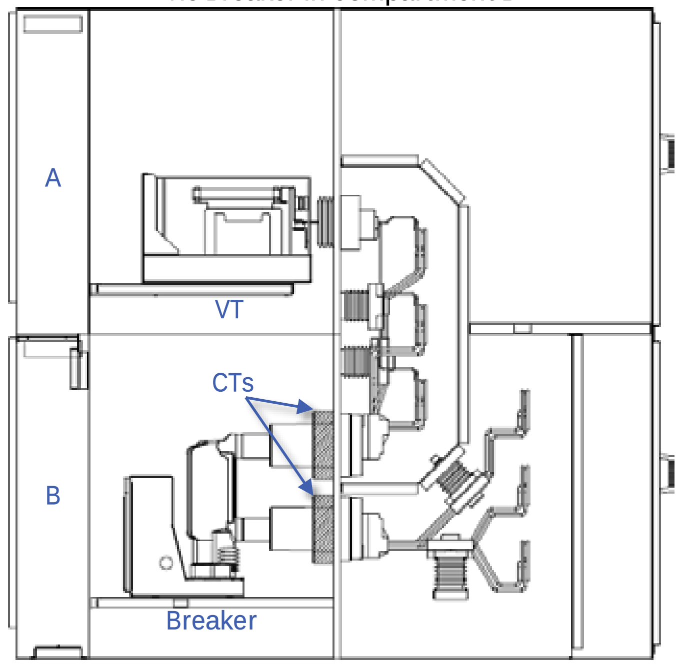


Figure 1-24: Breaker in Compartment A, Bus-connected VTs and Line-connected Fuse Rollout in Compartment B

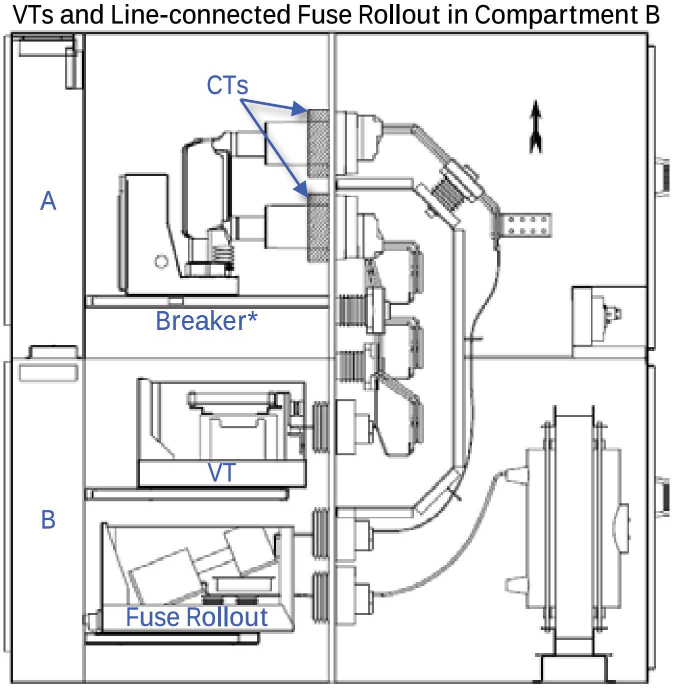
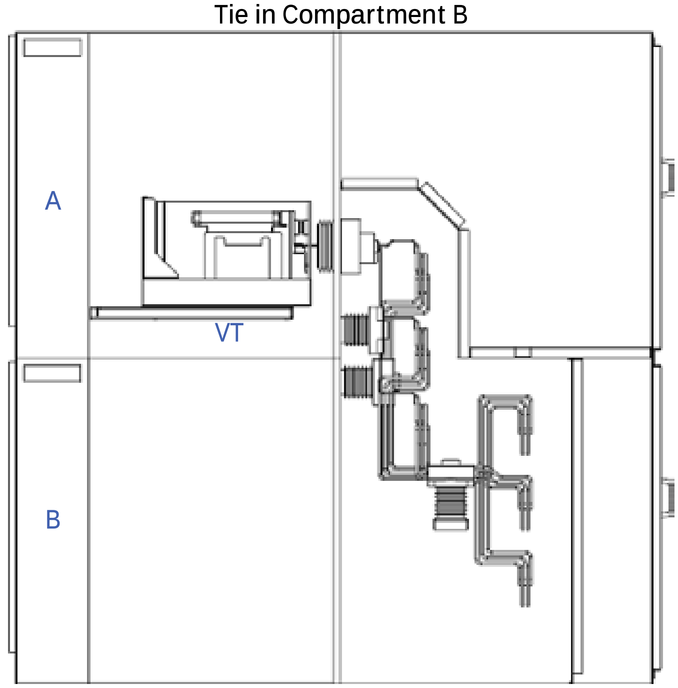


Figure 1-26: Bus-connected VTs in Compartment A, Aux Tie in Compartment B



SECTION 2. CIRCUIT BREAKER SELECTION

ANSI-C37.100 defines a circuit breaker:

> *A mechanical switching device, capable of making, carrying, and breaking currents under normal circuit conditions and also, making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit.*

Figure 2-1: SecoVac VB2+ Circuit Breaker

The function of a circuit breaker is to carry and switch load current and to interrupt short-circuit current when required. A circuit breaker can be used to operate frequently or infrequently, depending on the type and application. To properly select a circuit breaker, it is important to consider that the rating of the circuit breaker must equal or exceed each of the calculated duty requirements of the circuit in which the breaker is applied.

CIRCUIT BREAKER RATINGS

SecoVac VB2+ circuit breaker ratings are shown in Table 2-1. Interrupting ratings are intended for 60 Hz and 50 Hz applications. Table 1-2 and Table 1-3 show more information on service conditions, definitions, ratings, test and other applicable terms listed in ANSI and NEMA standards.

SELECTION CONSIDERATIONS

Circuit breaker selection is based on the duty requirements. For your application, find the model SecoVac VB2+ circuit breaker rated for those specifications (Table 2-1). It is important to consult the ANSI Standard C37.010 for proper guidance on duty requirements (see "Related Circuit Breaker References," item 2).

When selecting a circuit breaker, you must consider several characteristics such as circuit voltage, system frequency, continuous current, short-circuit current and closing and latching current.

Circuit Voltage

ANSI standards determine that the nominal voltage classes for medium voltage metal-clad switchgear are 4.16 kV, 7.2 kV, and 13.8 kV; in accordance with ANSI, SecoGear switchgear is designed to operate at a voltage range from 2,400 V through 15,000 V.

System Frequency

SecoGear Metal-clad switchgear is rated to 60 Hz as a standard with the option to provide a 50 Hz solution as required. When determining the system frequency of any switchgear, remember that the frequency rating should be the same as the nominal frequency of the power system.

Short-Circuit Current

One of the first things to consider when selecting a circuit breaker is the interruption rating of short-circuit current, for any SecoVac VB2+ circuit breaker, the interrupting rating is stated in three-phase, symmetrical, rms AC amperes.

Start by calculating the short-circuit current duty, followed by selecting the required voltage class, and finally determine the short-circuit current capability of SecoVac that equals or exceeds the expected duty.

Table 2-1: SecoVac VB2+ Vacuum Circuit Breaker Characteristics

Characteristic		1200/31.5 Rating	1200/40 Rating	2000/40 Rating
Rated current[1]		1200 A	1200 A	2000 A
Rated voltage (max.)		4.76 kV, 8.25 kV, 15 kV	4.76 kV, 8.25 kV, 15 kV	4.76 kV, 8.25 kV, 15 kV
Nominal ANSI voltage class		4.16 kV, 7.2 kV, 13.8 kV	4.16 kV, 7.2 kV, 13.8 kV	4.16 kV, 7.2 kV, 13.8 kV
Rated frequency		50 Hz, 60 Hz	50 Hz, 60 Hz	50 Hz, 60 Hz
Rated dielectric withstand test voltage	Power frequency rms voltage	36 kV	36 kV	36 kV
	Crest impulse voltage	95 kV	95 kV	95 kV
Rated short-circuit current (max interrupting capability) [2]		31.5 kA	40 kA	40 kA
Rated interrupting time		3 cycles	3 cycles	3 cycles
Rated permissible tripping delay		2 s	2 s	2 s
Short time current carrying capability		31.5 kA	40 kA	40 kA
Close and latch current peak (2.6 x short-circuit current rating)		82 kA	104 kA	104 kA

Notes:
1. Maximum voltage for which the breaker is designed and upper limit of operation.
2. At system operating voltages equal to or less than rated maximum voltage.

Closing and Latching Current

The function of any circuit breaker is to close and stay latched, during which the breaker goes through a first-cycle maximum asymmetrical rms current. In common applications, the standard close and latch capability meets the requirements and specification of the circuit.

However, in certain applications that can include large motor loads, the first-cycle asymmetrical short-circuit current exceeds the closing and latching capabilities of the selected breaker. If this situation arises, the circuit breaker selection will be based, in most cases, on the closing and latching capability of the next higher short-circuit current.

The closing and latching capability (kA, rms) of the circuit breaker is expressed in peak amperes. The value is equal to 2.6 times rated short-circuit current for 60 Hz and 2.5 times for 50 Hz.

Continuous Current

To select the proper SecoVac VB2+ breaker, calculate the continuous current duty based on the loads of the feeders and main breaker and identify a continuous current rating equal to or greater than the load current.

SecoVac circuit breakers are 100% rated with no continuous overload rating. For special applications with long-time overload rating such as motors, generators or transformers, it is important to consider that all of the switchgear equipment (including circuit breakers) must have a continuous current rating at least equal to the overload rating of the special apparatus. Consult ANSI C37.20.2 for overload current capability guidelines.

Rated Interrupting Time

SecoVac VB2+ circuit breakers are available only with interrupting ratings of 3 cycles, as stated in Table 2-1.

Duty Cycle

SecoVac VB2+ circuit breakers have a rated duty cycle of O - 0.3s – CO - 180s – CO.

SPECIAL SWITCHING APPLICATIONS

Application of power circuit breakers for switching duty may require derating of the circuit breaker, or increased maintenance. SecoVac VB2+ circuit breakers do not require derating when applied in automatic reclosing duty. For these applications, like capacitor switching, the usual practice is to first select a circuit breaker based on the criteria provided under "Selection Considerations," above. Then, consider the switching duty and, if necessary, re-determine the circuit breaker capabilities (continuous-current rating, interrupting rating, etc.). Also, factor in any modified operating or maintenance requirements.

Recheck the circuit breaker's evaluation capabilities against all the basic duty requirements under "Selection Considerations." If the circuit breaker selected initially, and as derated (or otherwise modified), no longer meets the duty requirements of the application, choose the next-higher-rated breaker. Repeat the derating or rating adjustment process to confirm that the new breaker has adequate capability.

Automatic Transfer

To improve system reliability and ensure supply to critical loads, primary or secondary selective system designs are often utilized. In these configurations, two or more otherwise typical radial buses are connected together via tie breakers. In normal operating mode, each bus is served by its own source through normally closed main breakers, with the bus tie breaker open. If an outage occurs on one of the incoming supplies, the incoming breaker connected to that supply is opened, and then the bus is re-energized by closing the bus tie breaker to transfer the dead bus to the live (alternate) source.

To protect against damage to motors connected to the dead bus, the bus tie breaker is typically not allowed to close until the residual voltage on the effected bus has decayed to a safe level. After the lost source has been reestablished, the scheme provides two methods (auto and manual) to restore the system to normal configuration.

If the sources cannot be synchronized, the bus tie breaker must be manually opened before the open incomer can be manually closed. In this procedure, the incomer will be allowed to close only if the incoming source (line VT) voltage is above a “live” threshold and the load (bus VT) voltage is below a “dead” threshold value.

If the sources are synchronized, it is possible to manually close the open incomer with synch check supervision to parallel all three breakers. The scheme will then automatically open a breaker which had been previously selected to trip if all breakers become closed, in this instance the bus tie breaker. Note that if momentary paralleling is utilized, the equipment and breakers must be rated for the total available fault current from the combined sources.

The detection of an undervoltage event and the resulting transfer logic can be accomplished using either discrete protective relays, auxiliary relays and timers, or with a PLC and programming, or by using the various protective relay and logic features contained in today’s multifunction relays, such as Multilin SR850. In addition to a protective relay required for each of the three circuit breakers (both mains and the tie), it is required to connect one contact from a three-position switch to each breaker. This switch (device 43/10) is used to select the breaker that will trip after all breakers are closed. It is generally recommended that a two-position switch (device 43/83) with three contacts, be connected to each relay as an “Auto-Off” transfer scheme selector.

Because a relay is required for each the three circuit breakers, it allows bus-splitting. This operation is accomplished by setting the time overcurrent elements in the relay on the bus tie breaker to trip faster than the incomers, opening the bus tie before an incomer when operating from only one source.

Capacitor Switching

Capacitor banks are generally applied on both utility and industrial power systems to improve voltage regulation and system stability. SecoVac VB2+ circuit breakers properly equipped are applicable as circuit breakers for small shunt-capacitor-bank switching applications.

Table 2-2: SecoVac Breaker
Capacitor Switching Capabilities

Rated Max. Voltage	15 kV RMS
Rated Short-circuit Current	31.5 kV RMS
Single Bank Rated Capacitor Breaking Current (1200 A Breaker)	250 A
Switching Class	C2
Frequency	60 Hz

SERVICE CONDITIONS

ANSI defines specific service conditions as “usual” or “unusual” for the operation of metal-clad switchgear; based on factors such as altitude, temperature, humidity and a variety of others, like presence of atmospheric contaminants storage conditions and tamper resistance. ANSI C37.04 specifies service conditions for circuit breakers and ANSI C37.20.2 for metal-clad switchgear.

Usual Service Conditions

SecoVac VB2+ circuit breakers and the complete SecoGear switchgear assembly are designed for usual service conditions at their standard nameplate ratings;

- Ambient temperature range: maximum 40 °C [104 °F] and minimum -30°C [-22 °F]
- Altitude: maximum 1000 m [3300 feet]

Unusual Service Conditions

Abnormal Temperature

For special applications with unusual service conditions such as ambient temperature outside normal range (-30 °C [-22 °F] to 40 °C [104 °F], consult ANSI C37.20.2 for derating values applicable. Refer special or abnormal applications for evaluation.

Temperature Rise

The temperature of the buses and bolted connections in any switchgear assembly must not exceed 65 °C [149 °F] when operating under full load current, and the total hot spot must not exceed 105 °C [221 °F], as stated in ANSI C37.20.2. Connections to insulated cables must not exceed a 45 °C [113 °F] temperature rise, and an 85 °C [185 °F] hot spot temperature when operated at rated continuous current in rms amperes at rated frequency.

High Altitude

There are two characteristics to take into consideration when designing medium voltage metal-clad switchgear at altitudes above 1000 meters [3300 ft]: continuous current rating and dielectric withstand capability. Both of them use air as a heat transfer and a dielectric medium; however, at high altitudes it may result in excessive corona at operating voltages, which could cause an inability to operate due to dielectric breakdown of the air insulation due to the reduced air density.

SecoVac VB2+ circuit breakers and SecoGear switchgear use air for an insulating and cooling medium. At altitudes above 1000 meters [3300 ft] the air is thinner, causing a higher temperature rise and lower dielectric withstand capability. If we intend to use a SecoGear switchgear at high altitudes we need to use the correction factors (listed in Table 2-3) and apply them to the continuous current rating, the impulse withstand voltage and the power-frequency withstand voltage (1 minute), to obtain derated ratings.

If the *Voltage Correction Factor* is applied to the maximum designed voltage rating of 15 kV, 8.25 kV or 4.76 kV for metal-clad switchgear, it may not be possible to install the equipment at altitudes above 1000 meters [3300 ft] using their typical nominal system voltages. Another accepted option is to apply the voltage correction factors to the BIL rating of the switchgear using the equipment at their usual rated nominal voltage, providing a surge protection device on the load side of the switchgear (see ANSI C37.010, 4.2.2).

The *Current Correction Factor* is applied to the continuous current rating of the equipment only. It is necessary to derate the continuous current rating, because switchgear assemblies depend on the air for cooling and will have a higher temperature rise when operated at altitudes above 1000 meters. The short-time and interrupting current ratings on vacuum breakers are not affected by altitude variations. Since the Current Correction Factor is small and the actual continuous current duty is less than the equipment rating, current correction is typically not as serious a consideration as the voltage correction. An additional consideration is that often, at higher altitude, the ambient is reduced, which can offset the higher altitude continuous current derating effect.

NOTICE
The recommendations are subject to modification, depending on the actual system conditions.

Correction factors are different for switchgear and for power transformers. Any application to use metal-clad switchgear above 1000 meters [3300 ft] should be referred for evaluation.

Table 2-3: Altitude Correction Factors* for SecoVac VB2+ Circuit Breakers and SecoGear Switchgear

Altitude	Rated Continuous Current Correction Factor	Rated Voltage Correction Factor
1000 m [3300 ft]	1.00	1.00
1200 m [4000 ft]	0.995	0.98
1500 m [5000 ft]	0.991	0.95
1500 m [6000 ft]	0.987	0.92
2100 m [7000 ft]	0.985	0.89
1500 m [8000 ft]	0.970	0.86
1500 m [9000 ft]	0.965	0.83
3000 m [10000 ft]	0.960	0.80
3600 m [12000 ft]	0.950	0.75
4000 m [13000 ft]	0.940	0.72
4300 m [14000 ft]	0.935	0.70

* From ANSI C37.20.2 – 2015, Table 8.

“Unusual service conditions” include other factors that require special attention, such as the exposure to corrosive atmosphere, explosive fumes, excessive dust, steam, dripping water, or salt spray; also, exposure to abnormal vibration, shock, unusual transportation or special storage conditions. We should also evaluate installations accessible to general public and applications with special equipment requirements.

BREAKER ACCESSORIES

Each circuit breaker shall be provided with an auxiliary (S5) switch with two “a” and two “b” contacts to indicate if breaker is open or closed;

Optionally, each circuit breaker can be provided with a four-stage MOC switch with four “a” and four “b” contacts to indicate breaker open or closed status. In addition, each circuit breaker can be provided with a TOC (position) switch with four “a” and four “b” contacts indicating whether the circuit breaker is in the “Connect / Service” or “Disconnect / Test” position.

An option for an eight stage MOC switch or TOC position switch is available, providing eight “a” and eight “b” contacts.

Another optional feature for SecoVac VB2+ circuit breakers is an undervoltage trip device that monitors the circuit control voltage and trips the breaker if the control power drops below a preset value. Refer to SECTION 3. “Control Power Equipment” for more information.

BREAKER LIFT TRUCK

With every order, we provide one standard SecoVac VB2+ lift truck, which is required to reach the upper compartment rollout. (See Figure 2-2.)

Figure 2-2: Lift Truck

Any housekeeping pad placed under the switchgear, must be less than 4 in. tall for proper operation of the lift truck.

For maximum safety and ease of use, the lift truck will be locked to the switchgear when a device is being handled, either inserted or removed. The lift truck should be used to carry only SecoVac circuit breakers, roll-out transformer trays, and fuse rollouts. Using the lift truck for any other application may result in damage to the carriage or injury to personnel.

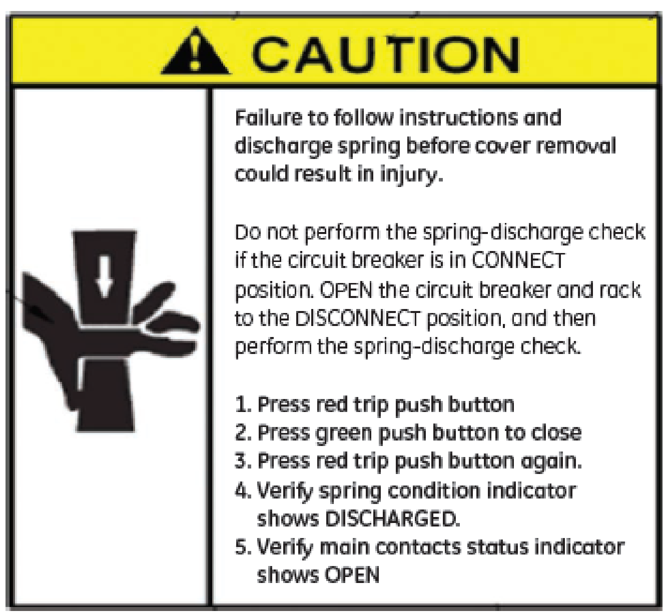
The lift truck requires a winch handle to raise or lower the carriage, and it will hold its position thanks to a clutch-break within the winch.

RELATED CIRCUIT BREAKER REFERENCES

1. IEEE Standard C37.06, Schedules of Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
2. IEEE Standard C37.010-2005, Application Guide for AC High Voltage Circuit Breakers.
3. IEEE Standard C37.04, Circuit Breaker Rating Structure.
4. IEEE Standard C37.20.2-2005, Metal-Clad Switchgear Assemblies.
5. IEEE Standard C37.100-2001 Definitions for Power Switchgear.

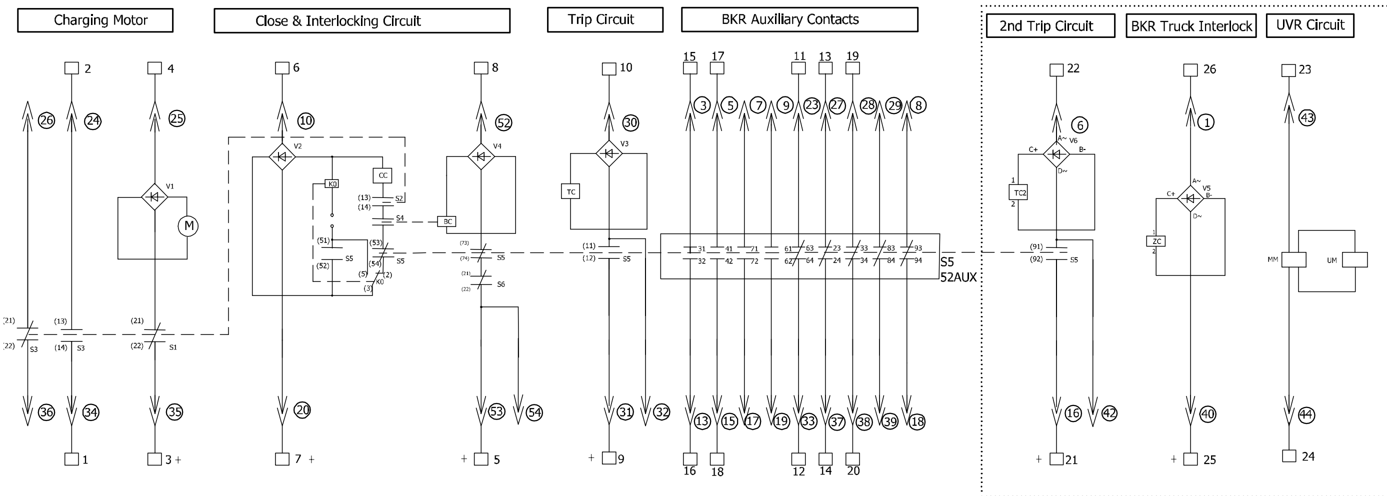
Figure 2-3: SecoVac VB2+ Breaker Front Panel

Figure 2-4: Spring Discharge Instructions



TYPICAL BREAKER DEVICE INTERNALS

Figure 2-5: System Wiring Diagram



S1~S3: Energy storing travel switch	Limit switch for trip free	TC2: 2nd Trip coil (optional)
K0: Anti-pumping relay Close Block Contact	TC: Trip coil M: Spring Charge Motor	MM UM: UVR coil (optional) BC: Close Block Solenoid
S5/52AUX: Auxiliary switch	CC: Closing coil	ZC: BKR Lock Solenoid (Optional)
V1~V6: Rectifier		

Key Note

- (xx) Auxiliary Contact Number.
- Ⓧⓧ Breaker Secondary Pin Number.
- ☐xx Switchgear Terminal block Number.

Notes:

1. This wiring diagram depicts a breaker that is open, racked to test position, with spring in discharge state.
2. Optional features are shown in the dotted box.

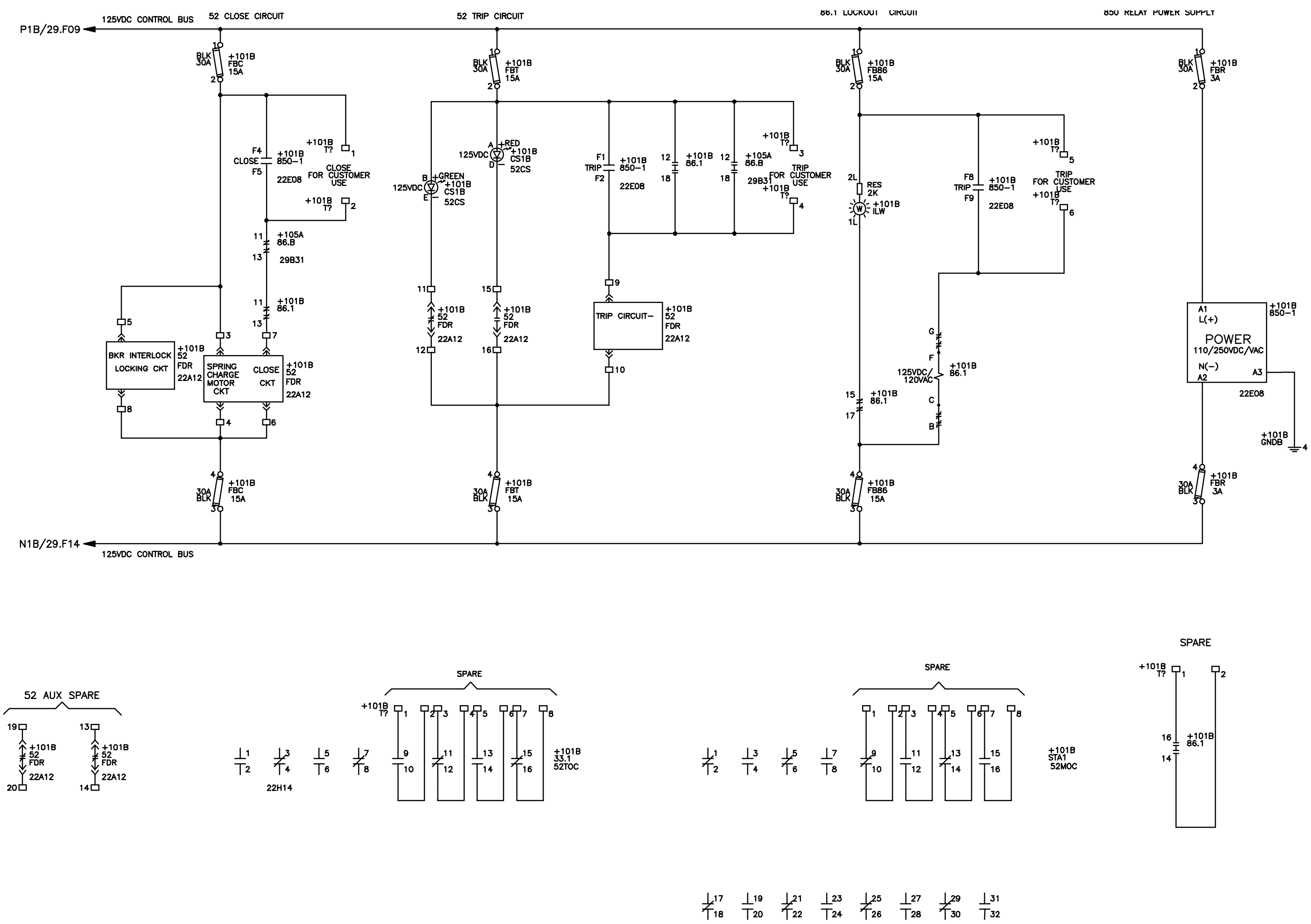
Figure 2-6: Terminal Block Located in Switchgear

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

Figure 2-7: Secondary Disconnect

47	43	42	1	2	3	4	5	6	7	8	9
45	10	11	12	13	14	15	16	17	18	19	20
49	50	51	52	53		54	55	56	57	58	
46	21	22	23	24	25	26	27	28	29	30	31
48	44	32	33	34	35	36	37	38	39	40	41

Figure 2-8: Example – Main Breaker Control Circuit, 850 Relay, Expanded MOC Switch



SECTION 3. CONTROL POWER EQUIPMENT

This section of the Application Guide provides guidance on control power requirements for SecoGear and equipment selection.

CONTROL POWER REQUIREMENTS

Control power for SecoGear needs to have enough capacity to provide the maximum power required at any operating condition. It is important to have adequate power for tripping of breakers during relay operation to protect the breakers and switchgear. Additionally, it should be capable of closing the breakers without direct manual operation.

Other load requirements for DC control power equipment include indicating lamps, relay power supplies, emergency lights, emergency motors, and excitation power (brushless motors, etc.); for AC control power equipment include indicating lamps, relay power supplies, excitation power (brushless motors, etc.), and equipment heaters.

The primary sources of control power for metal-clad switchgear are DC control from batteries with a charger, and AC control from a transformer. If using AC control power, the tripping power will be obtained through rectified AC, feeding capacitors contained within trip devices. There are several factors in determining the best alternative needed for each application, these can include system size, installation conditions, reliability, footprint, operation of breakers, maintenance, etc., and the end cost.

Breaker Close and Trip Considerations

For optimum operation of SecoGear Metal-clad switchgear, the selected source should provide a dependable power source sized to accommodate the required loads. The system should provide reliable operation of all of the electrically operated devices at their required operating voltage ranges. The required operating voltage range of the control power equipment is determined by the circuit breaker. These ranges are established by ANSI C37.06 standard. Refer to Table 3-1 for specific voltage ranges given each possible control source for SecoVac VB2+ circuit breakers.

Note that that spring charging time for SecoVac VB2+ mechanisms is approximately 3 s to 7 s.

Table 3-1: SecoVac VB2+ IEEE Circuit Breaker Control Voltages and Currents

Breaker Control Source Voltage	Closing Voltage Range	Tripping Voltage Range	Closing Coil Current	Tripping Coil Current	Charge Motor Inrush Current	Charge Motor Run Current[1]
48 Vdc	38 Vdc – 56 Vdc	28 Vdc – 56 Vdc	15.84 A	15.84 A	20 A	3.2 A
125 Vdc	100 Vdc – 140 Vdc	70 Vdc – 140 Vdc	2.78 A	2.78 A	8.8 A	1.2 A
250 Vdc	200 Vdc – 280 Vdc	140 Vdc – 280 Vdc	0.75 A	0.75 A	5.1 A	0.6 A
120 Vac	104 Vac – 127 Vac	108 Vac – 132 Vac[2]	2.78 A	2.78 A	8.8 A	1.2 A
240 Vac	208 Vac – 245 Vac	216 Vac – 264 Vac[3]	0.75 A	0.75 A	5.1 A	0.6 A

Notes:
1. Spring charge motor run time is <15 s.
2. 120 Vac control voltage for tripping requires the use of a 120 Vac capacitor trip device. Cap. trip device delivers 170 Vdc (peak) into a DC trip coil.
3. 240 Vac control voltage for tripping requires the use of a 240 Vac capacitor trip device. Cap. trip device delivers 340 Vdc (peak) into a DC trip coil.

Table 3-2: Contact Ratings for MOC, TOC, and Breaker Auxiliary Switches

Control Voltage	Current Rating of Contacts[1]
110 Vac/120 Vac	15 A
220 Vac/240 Vac	10 A
24 Vdc	15 A (max. 1 contact)
125 Vdc	10 A (max. 3 contacts in series)
240 Vdc	5 A (max. 6 contacts in series)
Control Voltage	**High-fidelity Current Rating**
125 Vac	0.1 A
8 Vdc – 30 Vdc	0.1 A

Notes:
1. Minimum operating current is 10 mA at 5 Vdc.

Breaker Tripping

SecoVac VB2+ circuit breakers have independent means for tripping, either manual tripping through a push button or electrically actuated through a trip coil. Electrically actuated tripping devices, can be used to open the breaker in normal switching conditions, initiated by an operator, or to automatically open the breaker as a protective response to abnormal conditions. Electrical tripping is accomplished when external power, from a battery or rectified AC source with capacitor, is directed into the breaker trip coil

Automatic tripping occurs when a protective relay senses an abnormal system condition through the power circuit instrument transformer, and closes output contacts in the trip circuit.

The following points must be considered when deciding between DC battery trip and AC capacitor trip:

The following points must be considered when deciding between DC battery trip and AC capacitor trip

- AC control may have lower cost than a battery system, but it will be necessary to install a separate trip device for each breaker and lockout relay

- Although battery system is more reliable, it requires more maintenance than a capacitor system (remember that a capacitor trip also contains a small rechargeable battery system that requires periodic maintenance and replacement)
- For a little additional cost, DC closing power can be obtained through the battery tripping system
- A small UPS should be included to power AC control in case of an emergency or power loss if no self-powered microprocessor relays are used
- A small UPS should be included to power AC control in case of an emergency or power loss if no self-powered microprocessor relays are used.

DC Battery Trip

When properly maintained, a battery bank is the most reliable tripping source. An added benefit is that it requires no auxiliary tripping devices and uses single-contact relays, which directly energize a single trip coil in the breaker. Power circuit voltage and current conditions during time of faults do not affect a battery-trip supply; therefore, it is considered the best source for circuit breaker tripping.

Once a battery bank has been selected for tripping purposes, it can, after proper evaluation of additional loads, also be used for breaker closing power. For indoor applications where a battery bank can be located close to the switchgear, a 48 V battery operating level is suitable. For more general use, a 125 V battery system is recommended. 250 V batteries can be used if other conditions require that voltage.

Reliability and long service life of the batteries will be possible only with proper maintenance, when kept fully charged. For equipment in remote locations with difficult access, where periodic maintenance is unlikely, the capacitor trip device may be a better option.

> **NOTICE**
> On indoor (NEMA 1) applications, batteries are typically not located within the switchgear structure.

SecoVac Autocharge Capacitor Trip Device

The ITI Automatic Charging Capacitor Trip Device (CTDB-6) is used to trip circuit breakers and lockout relays when AC control power source is utilized. The CTDB-6 converts AC control bus voltage to DC voltage and stores enough energy to operate a lockout relay or trip a circuit breaker, often more than once.

The CTDB-6, with batteries fully charged, will maintain a charge for a minimum of three days after the AC power has been interrupted. In normal operation, the batteries are trickle charged from the AC voltage source. The Autocharge Capacitor trip device is provided on SecoVac breakers whenever AC control voltage is specified. We offer for both 120 Vac and 240 Vac control power sources.

Direct Acting Undervoltage Trip Device

Most SecoVac circuit breakers can be provided with a direct-acting undervoltage trip device. The undervoltage trip device is a factory-installed unit, which is an integral part of the breaker mechanism. Its function is to monitor the DC trip control voltage and to mechanically trip the breaker if that control voltage is lost. The UV device will also block closing of the breaker if the control voltage is not 80% or more of the nominal value.

Breaker Closing

Closing power availability should also be independent of voltage conditions on the power system associated with the switchgear as the tripping. Accordingly, a DC battery bank is normally considered to be the most reliable auxiliary power source. Nevertheless, in many instances, the battery bank or other independent power source necessary to achieve this goal may require an investment, which is considered too high for the advantages gained. This is particularly true for small switchgear installations, consisting of only a few circuit breakers.

> **NOTICE**
> When initially installing SecoGear, to energize the control power equipment first establish the control power and then rack in SecoVac circuit breakers one at a time. This process will begin charging the closing spring of each breaker one by one, instead of trying to charge them all at once, preventing the risk of overloading the AC or DC source.

Besides from the economic factor that would be the primary decision to select AC or DC closing power, the following situations must be taken into account:

- Closing breakers with the power system de-energized
- Availability of housing space for a battery and its associated charging equipment
- Estimated ambient temperature extremes and the effect on battery capability
- Maintenance requirements for a battery and battery charger
- Expected future equipment additions, which may affect the present choice of closing-power source

When the closing mechanism is operated from AC, the current required is such that it can be taken from a control power transformer or a general purpose or lighting source, internal or external to the switchgear. The energy for the next operation is stored in the springs as soon as the breaker is closed.

To permit control switch or automatic initiation of closing, the AC source must also be present at the time of breaker closing to energize the spring-release solenoid (close coil). The SecoVac breaker mechanism is also capable of manual operation, if necessary, both for charging the springs and for releasing them to close the breaker.

For any control power source used for breaker closing, the maximum closing load should be calculated using Table 3-1. Usually, only one breaker will be closed at a time, but the possibility of simultaneous closing of two or more breakers must be examined. This possibility will depend on the type of application and any special control requirements, such as load restoration. Simultaneous closing of two breakers could occur with multiple-breaker, motor starting equipment, or with automatic reclosing breakers. Also, on large installations, with several different control points, different operators could cause simultaneous manual operations.

Indicating Lamps

Position indicating lamps are powered by the closing fuses on the AC control, the battery specifically used for tripping purposes, or the trip fuses on the DC control. Indicating lamps, represent a small, but steady load in the used in the calculation for DC battery applications. We assume for burden calculations 0.035 A per lamp for not more than eight hours. These lamps are used for supervision of the fuses in lockout relays, indicating lamps per breaker or for remote indication in parallel with switchgear lamps. Newer control switches and lockout relays may use indicating lights integral to the device, which must be considered in load calculations.

RELAYING

When using DC control power, the number of breakers to trip at one time must be considered in sizing calculations. This becomes critical for certain relay applications such as bus differential or load shedding. Table 3-3 provides a guide on the maximum number of breakers that can you can trip simultaneously.

Table 3-3: Simultaneous Breaker Tripping

Number. of Breakers in Lineup	Probable Max. Number of Breakers Tripped Simultaneously, per Cause: Time Delay Fault Protection	Instantaneous Fault Protection	Undervoltage or Bus Differential[2]
1	1	1	1
2	1	1	1
3 – 5	2	3	All
6 – 10	3	4	All
> 10	—[1]	—[1]	All

Notes:
1. Depends upon operating conditions.
2. Use of single undervoltage or bus differential relay for tripping all breakers.

If lockout relays are used as in differential relay circuits, the following actions should apply:

- With AC operation, each lockout relay must be provided with a capacitor trip device
- With DC operation, the breaker coils have to be energized in order for the relay to cut itself off in case of simultaneous breaker demand (Table 3-4)

Table 3-4: Type HEA Lockout Relay Coil Current Characteristics

Operating Voltage	HEA Relay Coil Current	HEA Relay Coil Resistance (@25 °C)
48 V	10.7 A	4.5 Ohms
125 V	5.5 A	23 Ohms
250 V	2.4 A	103 Ohms

EXCITATION POWER

When synchronous motors with brushless field excitation are controlled directly from the switchgear, power for the exciter field source is sometimes required from the switchgear control power source.

This excitation demand varies with the machine, from 1 A to perhaps 8 A DC, usually at approximately 100 V. With rectified AC supply to the field, the AC equivalent of the DC field current must be included the total CPT loading. (As a first approximation, multiply the DC amperes by 1.15 and convert to VA by multiplying this product by 125 V.) When the exciter field is fed directly from the battery, the field demand, as a nominal 8-hour load, must be included in the DC steady load total.

Generators with static regulators usually require a separate transformer on the incoming leads of the generator breaker. This transformer is of the same epoxy-cast coil, dry type, as the switchgear CPT, but is located in its own rollout tray. Such dedicated transformers are not part of the regular control power loading.

OTHER LOADS

When using the charger for DC control, you can use the switchgear AC control power transformer and include the load in the total AC demand. Using charger DC ampere rating as a base, some ratios of equivalent AC loads at different supply voltage and battery voltages (consult Table 3-5).

Table 3-5: AC Load Factor for Charger Battery Voltage

Supply Voltage	Load Factor for 48 Vdc Battery	Load Factor for 125 Vdc Battery
115 Vac	75 %	230 %
230 Vac	38 %	115 %

For example, a 6 A charger, fed 115 Vac, and supplying a 125 Vdc battery bank, has an AC load of approximately 13.8 A (6 A x 230%) at full output, or 1590 VA (13.8 A x 115 V). While this would be an intermittent condition, with the normal load being about 0.5 A to 1.0 A DC, the AC control source must be sized to handle the 13.8 ampere load.

With automatic control schemes, some relays will be energized continuously after the first breaker is closed. The amperes drawn by these relays must be totaled and included with the indicating lamp load, and others, to arrive at the total steady state load.

Emergency loads on switchgear batteries, such as room lights or DC pump motors will be powered only by a specific time and then extinguished; lights will usually be used for only three hours and the duration of a motor load must be specified by the user.

CONTROL POWER SOURCE SELECTION

To select the proper control power source including size of the battery and control power transformer, establish the size of the load, then, determine the short-time loads, such as breaker tripping and steady load; remember to convert to a common rate base.

Considering the relatively small demand loads on the control power source by individual breakers, it becomes critical to identify and total other loads, because these are the loads that may represent the major demand. Always keep in mind to set a period of time for longtime loads since a battery bank, with the charger “off,” is not a “continuous” source.

DC Control Power Equipment

We not design, manufacture, or test storage batteries. Switchgear Operations, when required, will select and furnish batteries and their charger as specified by the customer and in accordance with the requirements of the switching devices and the overall station operation.

The battery bank should be connected to the DC control power bus and the charger at all times, representing the complete DC control power equipment. The battery bank has plays a small part in the normal operation of the control power; however, it has a very important work to supply the large momentary loads.

Battery Systems

Lead-Acid Batteries

Common lead-acid battery types:

- Pasted plate, with lead-antimony grids
- Lead-calcium; a pasted-plate construction with calcium replacing antimony as the additive for grid strength

Pasted plate, lead antimony, is the basic lead-acid battery, familiar in another form as the automobile battery. For control work (compared to auto batteries), thicker plates and lower gravity of acid provide longer life and allow long-time trickle or “float” charging. With different plate thicknesses, expected life is from 6 to 14 years.

Lead-calcium construction has longer expected life (up to 25 years) than lead-antimony at a rather small increase in cost. The “pure lead” electrochemical characteristics, compared to the other classes, require slightly different (higher) charging voltages.

Nickel-Cadmium Batteries

Nickel-cadmium batteries are more expensive than lead-acid, in general, but have advantages. Maintenance is less; life is longer; low-temperature discharge currents are higher for a given size; and they can be charged more rapidly.

Pocket-plate cells are the normal construction used with switchgear; they are made in three different plate thicknesses. The thickest plates are not suitable for short-time applications. Medium or thin-plate cells are used with switchgear; the choice depending upon the relative amounts, respectively, or long- or short-time load.

Sintered-plate construction, which is relatively new, is used mostly in “cordless” appliances, seldom in switchgear.

Table 3-6: Battery Selection Guide

Factor	Lead-Acid	NiCad
Initial Cost	Lower	Higher
Maintenance	Higher	Lower
Life expectancy	Lower	Higher

Battery Capacity and Sizing

The capacity of a storage battery is usually expressed in ampere-hours (1 A for 1 h, or the product of amperes output multiplied by hours of discharge, with the basic rate being eight hours). Battery capacity, however, may be expressed at many time-rates other than the eight-hour rate.

For switchgear short-time loads, such as breaker tripping, the one-minute rate per cell (discharging to 1.75 V for lead, or 1.14 V for nickel-cadmium) is used. The one-minute rate does not exhaust the battery completely; rather, it is the rate that causes the terminal voltage to drop to the stated value early in the discharge period.

Further, the actual value of discharge capacity of a storage battery may vary over a wide range with battery temperature. Published data is for cells at 25 °C [77 °F], and battery rating factors must be reduced when the battery is at a lower temperature. For capacity rating factors refer to IEEE worksheets.

Generally, the effect of high temperatures for every 15 °F above 77 °F the lead-acid battery loses 50% of its useful life. For the same temperature decrease, the nickel-cadmium loses 20 % of its useful life. The one-minute rating at -10 °C [15 °F], for instance is half the 25 °C rating.

When calculating battery loads, you must consider three types of loads:

- Continuous loads are those that are energized for the duration of the duty cycle. These have a major effect of battery capacity.
- Non-continuous loads are energized for only a portion of the duty cycle. If the inception of the load is known, but the end is not or reverse, then you must consider it as the known portion of the duty cycle.
- Momentary loads are very short in duration, perhaps a fraction of a second, but you must treat it as lasting one full minute.

For more information, refer to the specification sheets or software programs provided by the battery manufacturer.

For direct calculation, the battery is assumed to have carried its steady loads for eight hours, and then as the worst case subject to the maximum load involving the one-minute rate.

Indoor locations assume that the battery is at 25 °C [77 °F]; outdoor locations at -10 °C [15 °F]. A minimum size limit of cell is suggested to allow for unknowns: 20 ampere-hours for lead-acid, or 15 ampere hours for nickel-cadmium.

A small station, for example, with the battery located indoors, might have three breakers, with closing and tripping duty, and no steady load except the switchgear indicating lamps. Two of the breakers have instantaneous settings on their overcurrent relays, so that per Table 3-3 simultaneous tripping of these two breakers might occur. Steady lamp load, thus, is 0.035 A x 3 = 0.105 amperes. Maximum short-time loads, given for both 48 Vdc and 125 Vdc to illustrate procedure, are shown in Table 3-9.

Table 3-7: Battery Sizing, Example A

Current	48 Vdc	125 Vdc
Trip coil	15.84 A	2.78 A
Spring motor	3.2 A	1.2 A

Since two breakers can trip at once in this example, maximum current from this load is either 15.84 A x 2, or 2.78 A x 2, respectively: 31.68 A or 5.56 A total at 48 Vdc or 125 Vdc. Comparing this with charging motor current, we see that the trip current is larger, so trip current will be used in the next step, shown in Table 3-8.

Table 3-8: Battery Sizing, Example B

	Lead-acid		Nickel-cadmium	
Current	48 Vdc	125 Vdc	48 Vdc	125 Vdc
Max. 1-min. demand	31.68 A	5.56 A	31.68 A	5.56 A
8-hr. equiv. (max. 1-min. demand / conversion factor[1])	21.12 AH	3.71 AH	10.92 AH	1.92 AH
Lamp load (0.105 A x 8 hrs.)	0.84 AH	0.84 AH	0.84 AH	0.84 AH
Total AH (amp-hrs.) at 8 hr. rate	21.96 AH	4.55 AH	11.76 AH	2.76 AH

1. Conversion factors to calculate “common rate base” (i.e., from one-minute rate to eight-hour rate) are: 1.5 for the lead-acid batteries (pasted plate); 2.9 for the nickel-cadmium batteries (thin plate or high rate). Please note that conversion factors vary by cell size; therefore, the factors used in this example are not applicable for batteries of other sizes.

Analyzing these totals, the lead-acid battery at 48 V with a nominal ampere-hour rating of 30 AH will be required. As an alternate at 125 volts, the minimum 20 AH lead-acid battery will be sufficient. The minimum nickel-cadmium battery of 15 AH will be sufficient at 48 V and at 125 V.

In addition, since the total ampere-hours required in each case is less than the ampere-hour capacity of the selected cell, reserve capacity is available. The matter of reserve capacity is largely related to how long the charger may be off. This no-charge condition has been known to last for several days. Thus, a “DC low-voltage alarm” option in the charger may be desirable to warn of such conditions.

For the same station, with the battery at outdoor temperatures, the one-minute demand must be doubled before converting to ampere-hours. The eight-hour rate needs a smaller increase of about 30 percent. Note that these conversion ratios generally decrease as cell size increases; hence, the approximate size of cell being considered must be determined before the conversion factors can be determined.

In arriving at the actual size of the battery bank, care must be taken to review the calculated amp-hours or cell requirement and then take into account the recommended design factor of 10% times the calculated values and then an aging factor of 25% times the calculated values. The combined sum of these calculations will provide the actual size of the battery bank.

Battery Chargers

Battery chargers have been built both as unregulated or “trickle” chargers, and as voltage-regulated chargers. The latter type provides longer life for the battery, particularly if it is a lead-acid battery. Voltage-regulated chargers are considered standard for switchgear applications.

The charger must be selected with an ampere rating sufficient to satisfy the simultaneous demand of the following three functions:

- Self-discharge losses of the battery.
- Steady load of the station: indicating lamps, relays, etc.
- Equalizing charges, or other high-rate output requirements. The self-discharge or “trickle” current of a lead-acid battery starts at about 0.25 % of the eight-hour rate, and increases with age to about 1.0 % of that rate. Nickel-cadmium cells can be assigned a similar trickle current. Steady load is made up of the long-time loads mentioned earlier in this section.

Equalizing charge is a monthly requirement for lead-acid batteries except for the lead-cadmium class. When the charger is first switched to the higher equalizing voltage, the battery demands current equal to about 20 % of its eight-hour rate.

Nickel-cadmium batteries do not require equalizing, but it is convenient to use the same numbers for lead-acid in establishing the charger capacity to be used for occasionally “boosting” the nickel-cadmium battery.

In sizing the charger, the first number considered should be the steady load from the preceding battery calculations. Add to this load the equalizing charge current. A quick way to find equalizing amperes is to divide the battery ampere-hour capacity (at the eight-hour rate) by 40. The sum of steady load and equalizing amperes is then compared with a list of battery charger ratings; select a charger with a rating that equals or exceeds this sum. The trickle current, unless known to be quite large, is usually covered by the margin between the standard charge rating and the sum of steady and equalizing loads.

Occasionally a battery is shipped “dry,” with electrolyte added at its destination. Such batteries require a “conditioning” charge after filling; the amperes needed for this are 25 % of the eight-hour rate, but with no other load connected.

AC CONTROL POWER EQUIPMENT

Control power equipment for SecoGear Switchgear, operated through an AC source should be powered from a separate transformer that will not be likely to be de-energized, in order to minimize the possibility of unexpected interruption of the control system.

Application

When energizing a switchgear from multiple sources, it’s necessary to operate breakers with a control power transformer depending on the source; when we are using applications that are not associated exclusively with a specific source like feeders or bus-tie breakers, we can use the transformer connected to the switchgear bus as a source or the control power transfer panel located in the switchgear, connecting the AC control bus to the energized transformer.

Selection

We can obtain the breaker tripping power from a capacitor-trip device for AC control; this option requires a relatively small demand for tripping and closing the breaker, and may not need to be included in the control power transformer section. However, conditions where two or more spring-charging motors are energized at the same time may require special caution.

> **NOTICE**
> When equipment is initially installed and control power is first energized, all connected SecoVac VB2+ breakers will immediately begin to charge their closing springs, which may overload the otherwise properly sized AC source. It is recommended to either connect the secondary plug of the breakers in one at a time after control power is established, or pull the close circuit fuse blocks or close circuit disconnects prior to energizing the control power circuit.

Let’s look at an example of a small indoor lineup. The configuration consists of five breakers and one auxilliary compartment in a four section lineup. Each breaker has a control switch and two indicating lights. The lineup has optional stack heaters and two convenience outlets. The lineup also has a requirement of 400 VA for remote lights. The load calculations are shown in Table 3-9.

Table 3-9: AC Load Estimating Example

Load Type	Load
Indicating lamps (0.035 A x 230 V x 5 breakers x 2 lights)	80 VA
Equipment heaters (300 W x 4)	1200 VA
Convenience outlets (500 W x 2)	1000 VA
Remote lights	400 VA
Total	2680 VA

GUIDE TO ESTIMATING HEAT LOSS

When operating at nameplate rating, SecoGear Metal-clad switchgear heat losses per section should be estimated by adding the individual components of heat loss as shown in Table 3-10 and then add each item from Table 3-11 as they apply in the switchgear line-up.

Table 3-10: Heat Loss per Breaker

Breaker and Bus Work Per Vertical Section	Heat Loss
1-1200 A breaker	485 W
1-2000 A breaker	880 W
2-1200 A breakers, stacked	944 W
1-1200 A & 1-2000 A breaker, stacked	1365 W

To the above figures add the following as they apply to the lineup:

Table 3-11: Heat Loss per Section

SecoGear Sections or Component	Heat Loss
Each vertical section with simple (typical) relaying and control	150 W
Each vertical section with complex relaying and control (differential relaying, backup protective relays, etc.)	330 W
Each VT rollout	50 W
Each CPT rollout up to 15 kVA	600 W
Equipment heaters if supplied (per section)	300 W

The following formulas convert Watts to BTUs:

- **BTUs per minute** = Watts x 0.05688
- **BTUs per hour** = Watts x 3.4128

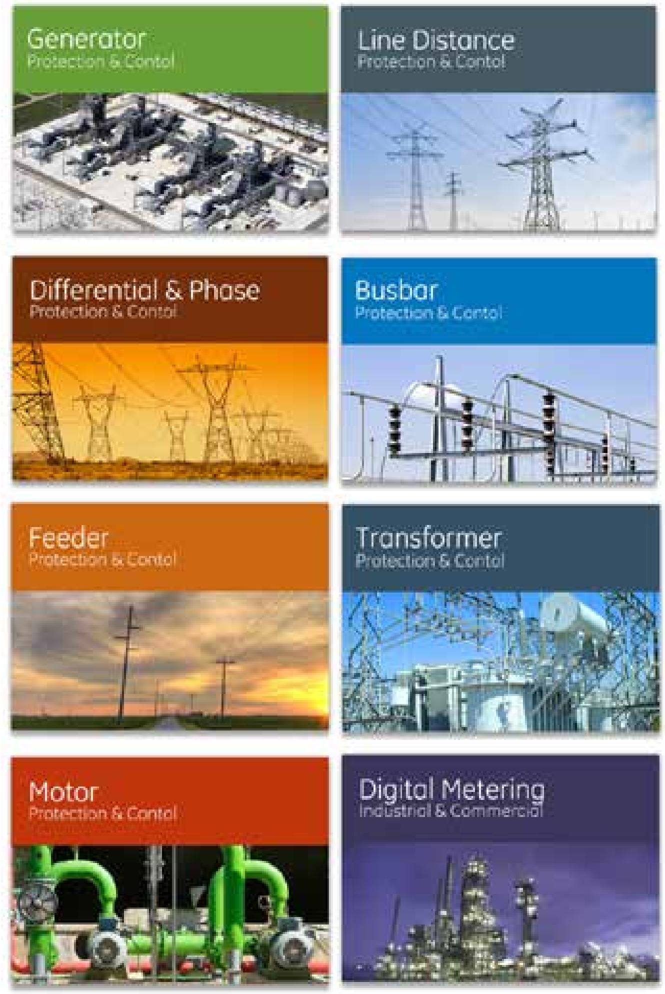
SECTION 4. SYSTEM AND EQUIPMENT PROTECTION

This section covers some basic considerations used when selecting relays for the protection of medium-voltage power systems. It is organized by protection packages with respect to equipment type generally encountered in medium voltage systems. Feeders, incoming lines, bus, transformers, motors, generators and metering will be covered.

Protection considerations can be provided by single-phase or multifunction three-phase relays, which may include phase and ground directional, non-directional relays, overcurrent, differential, directional power, under-frequency, and under-/overvoltage relaying.

Many benefits are provided by newer multifunctional digital relays; expanded relay functions, digital metering, diagnostics, reduction in relay costs per function, reduction in wiring and increased panel space with the reduction in the quantity of relays. Multilin Relay product reference guide can be found at www.GEMultilin.com or directly at

www.gegridsolutions.com/multilin/selector/



The Multilin website provides an easy reference to various relays and metering options available to you for use in your SecoGear equipment.

Figure 4-1: Multilin Website Features – Motor Protection Selection

Feeder Protection Selector Guide	350 Feeder Protection	850 Feeder Protection	F35 Multiple Feeder Protection	F60 Feeder Protection
Applications				
Parallel Feeders / Mesh Network Protection	—	—	—	—
Isolated Ground / Petersen Coil Compensated	—	—	—	—
Feeders with Reclosure Automation	●	●	—	●
Advanced Feeder Protection	●	●	—	●
LV/MV Bus Transfer Schemes (ATS)	—	●	—	—
Up to 6 Feeders in One Box	—	—	●	—
HIZ Fault Detection	—	—	—	●
Protection & Control				
32 - Directional Power	—	●	—	●
67N_2 - Dir., Negative Sequence	—	●	—	●
67P - Dir., Phase	●	●	—	●
67N/G - Dir., Neutral/Ground	●	●	—	●
50BF - Breaker Failure	●	●	Logic	●
50P - Instantaneous Overcurrent - Phase	●	●	●	●
50N - Instantaneous Overcurrent - Neutral	●	●	●	●
51P - Time Overcurrent - Phase	●	●	●	●
51N - Time Overcurrent - Neutral	●	●	●	●
51V - Voltage-Dependent Overcurrent	—	VCO/VRO	—	VCO/VRO

Figure 4-2: Multilin Website Features – Digital Metering Selection

	EPM 6000 Multifunction Power Metering	PQMII Power Quality Meter	EPM 7000 Power Quality Meter	EPM 9450 Advanced Power Quality Meter	EPM 9650 Advanced Power Quality Meter	EPM 9800 Advanced Power Quality Meter	EPM 9900 Advanced Power Quality Meter
	More Info	More Info	More Info	More Info	More Info	More Info	More Info
▼ Energy & Measurement Accuracy							
Active Energy Measurement Accuracy <0.2%	—	—	—	0.04%	0.04%	0.06%	0.06%
Active Energy Measurement Accuracy ≥0.2%	0.2%	0.4%	0.2%	—	—	—	—
Energy Accuracy Meets or Exceeds ANSI Class	C12.20/Class 0.2	—	C12.20/Class 0.2	C12.20/Class 0.2	C12.20/Class 0.2	C12.20/Class 0.2	C12.20/Class 0.2
Energy Test Pulse for Accuracy Certification	●	—	●	●	●	●	●
▼ Power & Energy Measurement							
Multi-circuit Measurement	—	—	—	—	—	—	—
Voltage, Current, Frequency, Power Factor	●	●	●	●	●	●	●
Power (kW, kVAR, kVA)	●	●	●	●	●	●	●
Bi-Directional Power	●	●	●	●	●	●	●
Energy (kWh, kVARh, kVAh)	●	●	●	●	●	●	●
Demand	●	●	●	●	●	●	●
Demand-Time-of-Use Support	—	●	—	●	●	●	●
Auto-calibrating	—	—	—	●	●	●	●
▼ Power Quality							
Harmonics - THD	●	●	●	●	●	●	●
Sags & Swells	—	●	●	●	●	●	●
Harmonics-Spectrum Analysis	—	●	●	●	●	●	●

BASIC SYSTEM PROTECTION

Phase Overcurrent Protection

Recommended phase overcurrent protection consists of one time and instantaneous phase overcurrent element (50/51) in each phase operated from a current transformer in each phase. This arrangement provides complete phase-overcurrent protection for the circuit, even when one phase element is removed from the circuit for testing; it also provides local backup if one of the three phase elements is inoperative.

Overcurrent relays are available with standard ANSI inverse, very inverse, or extremely inverse and definite time characteristics. Many microprocessor-based relays also offer these ANSI curve shape characteristics. In the absence of additional system information, for a single characteristic device the very inverse characteristic is most likely to provide optimum circuit protection and selectivity with other system protective devices.

This characteristic is intended for application where the magnitude of fault current is primarily determined by the distance from the source to the fault. The extremely inverse characteristic is well suited for applications in which selectivity with fuses or reclosers is a requirement. The inverse characteristic is useful in those rare applications in which selectivity with other inverse or definite time relays is a concern. It is also useful on systems that have a multiplicity of local generators at the distribution voltage and where the magnitude of fault current is determined primarily by how many generators are in service at the same time. Most microprocessor based relays have the entire above characteristics field selectable which would allow the specifier to select a relay with minimal information and select a characteristic when more complete information is available.

Incoming Lines

Incoming line phase-over-current protection is typically time delay only (51), furnished without instantaneous attachments (50), or on digital multi-function relays, the instantaneous is disabled, but the function stays available. This allows the relay to be selective with feeder relays having instantaneous attachments (50/51).

Feeders

Instantaneous phase-overcurrent relay (50) settings for radial *utility distribution feeders* are usually set as low as possible considering, among other things, “cold-load” pickup and other circuit requirements. Instantaneous phase-overcurrent relays for *industrial or commercial building radial circuits* are usually set high enough (but well below the available short-circuit current) to prevent false tripping for faults at the lower-voltage terminals of large transformer banks and to provide selectivity with groups of large motor starters. Instantaneous settings should be low enough so that the combination of time and instantaneous settings provides protection below the conductor short-circuit heating limit.

Multilin 350, or 850 digital multi-function relays provide complete incoming line or feeder protection and monitoring.

Feeder Ties

For feeder-tie (cable connected) circuits to *downstream* distribution circuit-breaker lineups, selectivity is enhanced by disconnecting, disabling, or delaying the instantaneous element (50) of the phase-overcurrent relays and setting the time-overcurrent (51) element to trip at less than the short-circuit heating limit of the conductors.

Bus Ties

Bus-tie circuits, within the same lineup of switchgear including two incoming lines, are frequently specified without overcurrent-protection. When overcurrent protection is provided for this type of circuit, relays are connected in what is termed a “current summation” connection. The use of this connection provides the opportunity for selectivity between main or tie breakers and feeder breakers minimizing relay operating time delay.

Transformers

Transformer-overcurrent protection criteria are specified In Section 450 of the 2005 National Electrical Code. Permissible short-circuit capabilities for transformers are specified in ANSI Standard C57.12. Selection of transformer-overcurrent protection is governed by these criteria.

NEC requirements determine the pickup of the time-overcurrent phase protective relays. The time dial setting is determined by ANSI requirements and the connection of the transformer. The inrush and short-circuit current magnitudes determine the instantaneous setting of the phase-overcurrent protective relays. The Multilin SR345, or SR845 relay provide options for transformer protection, metering, and monitoring.

Generators

Overcurrent relays, applied on generator circuits, are used for feeder backup rather than overload protection. These overcurrent relays are typically voltage-restrained overcurrent relays (51V). They operate faster and are more sensitive for faults close to the generator than for faults remote from the generator. The Multilin SR889 relay provides complete generator protection, metering and monitoring.

Ground Overcurrent Protection

Ground-overcurrent protection is provided by either time-overcurrent or instantaneous overcurrent relays. To minimize damage to circuit equipment and circuit conductors, sensitive ground-fault protection is desirable.

The three most commonly used connections for ground-overcurrent relays are the residual connection (51N), the ground-sensor (balanced-flux or zero-sequence) connection (50GS or 51GS), and the neutral current transformer connection (51G).

Residually connected ground-overcurrent relays (51N) are wired in the ground (neutral)-return current transformer lead of three current transformers connected in wye. The relay detects the current of a ground fault by measuring the current remaining in the secondary of the three phases of the circuit as transformed by the current transformers.

The minimum pickup of the relay is determined by the current transformer ratio. On systems with line-to-neutral connected loads, the ground-overcurrent relay (51N) pickup must be set above any expected maximum single-phase unbalanced load. If an instantaneous ground-overcurrent element (50N) is used, it must be set above any expected unbalance due to unequal current transformer saturation on phase faults or transformer inrush currents. Residually connected ground-overcurrent relays are usually applied on solidly grounded systems.

Ground-sensor (GSCT) relaying schemes use an instantaneous (50GS) or time-delay (51GS) overcurrent relay or relay element connected to the secondary of a window-type current transformer through which all load current-carrying conductors pass. The relay detects the ground current directly from this current transformer, provided the equipment ground conductor and cable shielding bypass the current transformer. Ground faults 15 A (or less) in the primary circuit can be detected with this scheme. Ground-sensor relaying schemes are usually applied on low-resistance or solidly grounded systems.

Neutral ground relaying typically uses a time-delay overcurrent relay (51G) connected in the secondary of the current transformer, located in the neutral of a wye-connected transformer, wye-connected generator, or the neutral of a neutral-deriving transformer bank.

Some systems are designed with no intentional grounds. To detect the first ground on this type of system, a sensitive directional ground overcurrent device may be employed. Optionally, a set of potential transformers wired wye-wye or wye-broken delta with indicating lights or voltmeters can be used to indicate the presence of a ground fault on an otherwise ungrounded system.

Incoming Lines

Incoming line ground-over-current relay protection consists of either a residually connected relay (51N) or a relay (51G) connected to a current transformer in the transformer neutral ground connection. Ground-sensor relaying (51GS) on incoming lines is not recommended because of the size, number, and construction of the incoming line conductors.

For solidly grounded systems with source transformers located remote from the switchgear, residually connected ground-overcurrent relays (without instantaneous) are most often applied. Some utility users omit all incoming line ground relays on solidly grounded systems and rely on three phase-overcurrent relays to provide complete phase- and ground-fault protection.

For impedance or resistance grounded systems with local source transformers, a ground relay (51G) connected to a current transformer in the transformer neutral connection is most applicable. A typical current transformer ratio for the neutral current transformer is one-half to one-quarter the maximum ground-fault current (e.g., a 200:5 CT ratio is appropriate for the neutral CT in series with a 400 A, 10 s neutral grounding resistor). This ratio permits sensitive settings of the ground relay and selective operation with downstream ground-sensor relays. The ground relay is the system backup relay for the medium voltage system. It also provides ground-fault protection for the transformer and its secondary conductors. If a transformer primary circuit breaker is used, the secondary ground-overcurrent relay (51G) in the transformer neutral connection should trip both the transformer primary and secondary circuit breaker.

Feeders

Ground-sensor (zero-sequence) relay arrangements use instantaneous-overcurrent relays (50GS) or time-overcurrent relays (51GS) and are appropriate for both resistance grounded and solidly grounded systems. These arrangements provide sensitive ground-fault protection for both branch circuits and feeder-distribution circuits.

Good selectivity can be obtained for a distribution system incorporating this type of relaying on all branch and feeder distribution circuits; however, a feeder breaker with ground-sensor relaying usually cannot be made selective with downstream feeders using residual ground relaying. In addition, ground-sensor relaying is not applicable to circuits with metal-enclosed conductors (non-seg Bus Duct) because of the impracticability of passing the phase conductors through a single current transformer.

Ground-sensor relaying is rarely applied to circuits terminated with potheads because of the special mounting installation procedures required.

Residual-ground relaying (51N or 50/51N) is suitable for feeders on solidly grounded systems or resistance grounded systems with available ground-fault currents greater than about twice the maximum current transformer rating. It is also required for feeders, which must be selective with other downstream feeders having residual-ground overcurrent relaying.

Transformers and Generators

Ground-overcurrent relaying for wye-connected transformers, wye-connected generators and neutral-deriving transformers usually employs neutral-ground relaying, as discussed previously under “Incoming Lines.” This provides system backup ground relaying. Settings, however, are normally too high to provide good ground-fault protection for the apparatus. Ground-fault protection is better obtained by using a scheme of differential relaying, as described later in this section.

Directional Phase Overcurrent Protection

Directional phase-overcurrent relays (67) operate for current flow in only one predetermined direction. Incoming lines, operating in parallel from separate sources, require directional phase-overcurrent relay protection to provide sensitive operation and to assure selectivity between incoming-line breakers for phase faults on the source side of one of the breakers.

This directional phase- overcurrent protection is furnished by using relays, polarized to operate on current flowing toward the source. The directional-overcurrent relay without instantaneous function is appropriate for most applications. The pickup of this relay should be set at a value slightly below full-load current. The time delay function can be set to permit selectivity with upstream feeder breaker or line instantaneous relays.

Occasionally a directional-overcurrent relay (67) with directional instantaneous function is applied to incoming lines fed by long “dedicated” service lines; the instantaneous directional unit is set to operate for faults located approximately 80 % to 90 % of the distance from the incoming line to the source.

For large local transformers, the instantaneous unit on a high side directional overcurrent relay is set slightly above the low-voltage symmetrical rms amperes contributed through the transformer to a fault on the higher voltage side of the transformer.

Directional phase-overcurrent relays can be voltage-polarized from bus VTs connected in open-delta, delta-delta or wye-wye. Polarization is necessary to establish the current phase relationships between voltage and current to determine the direction of current flow.

While earlier electromechanical directional-overcurrent relays usually had only one time-current characteristic, digital multifunction versions are available in three-phase (and ground, if desired) packages with inverse, very inverse, and extremely inverse (and other) characteristics that are field-selectable.

Directional Ground Overcurrent Protection

Incoming lines operated in parallel from separate grounded sources require directional ground-overcurrent relays (67N) to assure selectivity between incoming-line breakers for ground faults on the source side of each of the incoming-line breakers. For solidly grounded systems and many impedance-grounded systems, a multifunctional digital relay usually is appropriate. This relay is set at a low pickup to permit selectivity with the other incoming-line non-directional ground-overcurrent relaying.

All directional-ground relays must be polarized. For systems with local, grounded supply transformers, the current transformer located in the transformer neutral-ground connection may be used for polarizing. For systems with remote-supply transformers, a set of local wye-broken delta connected voltage transformers (or wye-wye VTs with wye-broken delta auxiliary transformers) may be used for polarization. On occasion, dual polarization may be desirable.

As mentioned in the phase units above, digital versions are available in packages with inverse, very inverse, and extremely inverse (and possibly other) characteristics field-selectable. This function (67N) may also be packaged in with all three phases of directional phase overcurrent.

High Impedance Ground Fault Detection

Many distribution system ground faults do not generate enough current to be detected by traditional overcurrent protection. These faults frequently result from a broken conductor falling in contact with a poor conducting surface or an object having relatively high impedance (e.g., tree branches, dry ground). A high percentage of arcing downed conductors may be detected by new digital relays with “high Z” capabilities, specifically designed for this purpose, such as Multilin F60 Feeder Protection Relay.

Differential Protection

Differential protection is a method of equipment protection in which an internal fault is identified by comparing electrical conditions at all incoming and outgoing terminals of the equipment. By virtue of the connection and settings, this protection operates only for faults in the apparatus being protected, or “in the zone of protection.” Hence, differential protection does not need to coordinate with devices protecting other downstream conductors and equipment. Differential protection considerations for specific equipment is discussed in later sections.

Bus Protection

Bus-differential relays should be applied to generator buses, buses with high available short-circuit current, and buses that, if faulted, create system disturbances that could lead to system instability in other portions of the system if the fault is not rapidly isolated. High-speed bus differential can also reduce the level of incident energy released during an internal arcing fault, increasing operator safety and reducing equipment damage.

This type of relaying uses equally rated phase-current transformers of like characteristics in each circuit connected to or from the bus to be protected. Multilin offers three-phase bus-differential relays (87B) with the B30 and B90 relays. B30 can be used on a high-impedance bus differential with the addition of the Multilin HID module. B90 is for low-impedance applications.

Transformer Protection

Transformer-differential relays (87T) are high-speed relays with harmonic restraint. These relays use current transformers of different ratios and connections and compensating relay taps. Liquid-filled transformers, larger than approximately 5000 kVA, are protected usually with both differential and fault-pressure relays (63FP) and occasionally with gas-detector relays.

Differential relays protect the internal transformer circuit, including conductors, bushings and windings. Fault-pressure relays provide excellent internal tank-fault protection for liquid-filled transformers, but do not include the entire circuit in the protected zone.

Transformers connected delta-wye, with the secondary neutral grounded through resistance, frequently require ground-fault as well as phase-fault differential protection because the pickup of phase-differential relays may not be low enough to detect secondary ground faults. This results from the large CTs necessary to carry transformer load currents at forced air ratings. For such systems, the Multilin SR845 Transformer Protection relay can be used for complete protection.

Motors

Motor differential relays are usually applied to motors 1500 HP and larger. Three-phase motor-differential relays (87M) used for this application employ the balanced-current principle. This type of protection provides for detecting motor-fault currents as small as 15 A. In some applications, differential relay schemes are used to protect both the motor and its feeder cable. These schemes use three CTs on each side of the motor.

Transmission Line

Line-differential protection (87L) for short lines and important tie lines between medium-voltage switchgear lineups is obtained by using transmission line relays. These relays compare the currents at each end of a two-terminal line. These high-speed relays are sensitive to both phase and ground faults. Typical relays for this application would be L30, L60, L90, as well as D30, D60 and D90 Distance series relays.

Generators

All generators should be protected with differential relaying. Generator-differential relays (87G) are high-speed relays sensitive to phase faults and many ground faults. These relays compare the currents in and out of generators using three CTs on each side of the generator. For small generators, balanced-current-differential relaying may be used. This type of relaying is described under “Differential Protection: Motors.”

Open Phase Protection

Incoming line open-phase operation occurs when one conductor is opened due to a single upstream fuse’s melting, or a single-line conductor’s or circuit breaker pole’s opening. System protection for either of these events for systems without local generation consists of a negative-sequence voltage unbalanced relay (60). To avoid tripping on system transient disturbances, this relay should operate through a time delay usually set from 2 s to 4 s. For systems subject to harmonics, a harmonic filter applied to the input to this relay may be required. The negative-sequence voltage function (60) may also be incorporated in a multifunction motor protection relay.

Automatic Reclosing

Radial feeders supplying overhead lines — with or without line sectionalizing — sometimes employ automatic reclosing for better service continuity. Relaying for this type of application is used for open-wire overhead circuits, which are prone to develop non-persistent faults. A series of three or four attempts to close a breaker at variable times may either be programmed with an immediate initial reclosure or an initial time-delay reclosure. A multi-shot automatic reclosure option is utilized for this function.

The use of the immediate initial reclosure option is not recommended on feeders serving large motors or on feeders originating on a generator bus. Frequently, the automatic reclosing relay is programmed to block an instantaneous overcurrent relay (50 or 50N) after the initial trip, for part of or all of the reclosing schedule. This function may also be incorporated as part of a multifunction microprocessor-based protection relay, which is directional or non-directional.

Directional Power, Underfrequency, and Undervoltage Protection

Systems with local generation or large motors require relaying to detect fault conditions on the utility tie circuit or to detect loss of the utility source. Relays used to detect these circumstances should be high-speed to trip the utility tie prior to any automatic reclosing operations and to promptly initiate any programmed load shedding. Complete protection for these circumstances is provided by a combination of functions including underfrequency (81); a sensitive directional-power (32); and undervoltage (27). For some applications where the (32) and (27) functions are only instantaneous, a timer is used which is set at about 0.2 s.

The directional-power element may be connected to current transformers either in the incoming line circuit or in a large motor circuit depending on the application. A study of the specific system is required to select the appropriate relays and connections for this type of protection.

Multilin multifunction relays, such as SR889 or G60, use a combination of relay functions including underfrequency (81), sensitive directional-power (32), undervoltage relay (27), and timing functions to provide complete protection.

ARC FLASH DETECTION

An arc flash is the sudden release of electrical energy through the air, following a fault. The event can produce extreme temperatures of up to 35,000 °F, which can cause severe damage and possible harm to employees. Due to the nature of these events, reliable arc flash detection is critical to avoid damage.

Two methods are commonly used: light and pressurized sound signal detection. The Multilin A60 utilizes Light and Pressure Sensor Technology to detect an event and quickly send a signal to trip your breaker and remove the energy source.

An alternate to the use of the A60 system is the Multilin 8 series relay along with the optional Arc Flash module with optical sensors. The 8 Series relay and arc flash sensors will detect light from an event and send a signal to trip your breaker. The 8 series relay uses a combination of light detection and overcurrent to reduce false indications by some non-event light source.

Consult the Grid Solutions website for additional details on the A60 and 8 Series relay systems: www.gegridsolutions.com/products/brochures/.

BASIC EQUIPMENT PROTECTION

Circuit Breaker Control and Control Power Protection

Basic circuit breaker control consists of a control switch located at the breaker, to close and trip the breaker. Associated with the control switch are two indicating lamps, one red and one green. The red lamp indicates a closed breaker and supervises the trip coil integrity. The green lamp indicates an open breaker. This lamp is connected through a breaker “b” contact.

For switchgear applications requiring remote control, a permissive control (69CS) function is available. This function provides local or remote control of a circuit breaker under certain defined conditions, and is available in three schemes as shown in Table 4-1. Scheme C is recommended for remote control, since it provides maximum operating flexibility.

When a local “trip” operation is initiated, the breaker cannot be closed remotely until the local switch handle is returned to the “NORMAL AFTER CLOSE” position. When the breaker is in the “TEST” position, closing and tripping can only be done locally.

SecoVac VB2+ circuit breakers have a spring-operating mechanism, consisting of a single module. The operating mechanism is equipped with manual charging device which uses a charging handle, and an electric charging device which charges the spring via a motor. The mechanism has reclose function. The front panel of the circuit breaker shows Open/Close and Charged/Discharged indicators and has a manual operating handle. The operator can charge the spring remotely, manually, or by electric power, and the status of the circuit breaker can be observed on the front panel (Figure 2-3).

Table 4-1: Remote Control Schemes

Control Location		Local				Remote				Devices Required (in addition to remote control switch)
Breaker Operation		Close		Trip		Close		Trip		
Breaker Position		Conn	Test	Conn	Test	Conn	Test	Conn	Test	
Remote Control Scheme	A			X	X	X	X	X	X	Local permissive switch (69CS), plus breaker position switch (52POS)
	B		X		X	X		X		Local permissive switch (52CS), plus breaker position switch (52POS)
	C*		X	X	X	X		X		Local permissive switch (52CS), plus breaker position switch (52POS)
Basic Control		X	X	X	X					Control switch (52CS)

Key:
X = This manually initiated operation is possible.
* = This scheme uses same devices as scheme B, but different wiring.

Instrumentation, Current, and Voltage Transformers

Basic current or voltage indication in SecoGear switchgear can be via a switchboard type analog meter and transfer switch, a digital meter, or can be a feature of a multifunction protective relay. Most solid-state multifunction relays today offer some type of metering capabilities, including voltage, current, watts, vars, frequency, and the demand functions.

AM and VM Scales

Ammeter scales are determined by the CT ratio. Current transformer ratings are normally selected based on approximately 125 % of the ampacity of the feeder circuit conductors. Current transformer ratios selected in this manner permit settings of circuit overcurrent-protective relays to provide good selectivity and protection. For a properly designed circuit, operating at full load, this means a maximum scale reading of between half and three-quarter scale.

For a circuit that provides for substantial future expansion, lower scale readings will indicate initial-load conditions. The voltmeter scale, determined by the voltage transformer ratio, is 125 percent of the nominal line-to-line VT rating. Optional wattmeters and varmeters, switchboard type, are available for most equipment. Wattmeter and varmeter scales are determined by the CT and VT ratios.

CT and VT Ratios

Standard window-type current transformers are available in ratios ranging from 50:5 to 4000:5 amperes. The basic ground-sensor window-type CT (GSCT) ratio is 50:5 amperes, with a 7.25 in window. Relay accuracy class is per IEEE C37.20.2-2015, Table 4. Higher accuracy classes may be available; however, space for mounting such CTs is limited.

Table 4-2: Single Ratio CTs

CT Ratio	Standard Accuracy Class	High Accuracy Class[1]
50:5 A		C10
100:5 A	C10	C20
150:5 A	C20	C50
200:5 A	C20	C50
250:5 A	C20	C50
300:5 A	C20	C100
400:5 A	C50	C100
500:5 A	C50	C100
600:5 A	C100	C200
800:5 A	C100	C200
1000:5 A	C100	C200
1200:5 A	C200	C400
1500:5 A	C200	C400
2000:5 A	C200	C400
2500:5 A	C200	C400
3000:5 A	C200	C400
4000:5 A	C200	C400
5000:5 A	C200	C400

Note:
1. High accuracy requires twice the mounting space of a standard accuracy CT.

Table 4-3: Multiple Ratio CTs

CT Ratio	Standard Accuracy Class	High Accuracy Class
600:5 A 50/100/150/200/250 300/400/450/500/600	C100	C200
1200:5 A 100/200/300/400/500 600/800/900/1000/1200	C200	C400
2000:5 A 300/400/500/800/1100 1200/1500/1600/2000	C200	C400
2000:5 A 300/400/500/800/1100/ 1200/1500/1600/2000	C200	C400
3000:5 A 300/500/800/1000/1100/ 1500/2000/2200/2500/3000	C200	C400
4000:5 A 500/1000/1500/2000/2500 3000/3500/4000	C200	C400

Metering and Test Block

Current transformer relaying accuracy and excitation characteristics are particularly important when considering lower-rated current transformers on systems with high available short-circuit currents and for all differential relay applications. Excitation characteristics and accuracy classes are available upon request.

Standard voltage transformers are mounted in rollout trays, with primary and secondary fusing. Models are available rated for line-to-line, or line-to-neutral applications with system voltages from 2400 V to 14400 V.

Control and Transfer Switches

Series 95 control and transfer switches are furnished, or as specified. Test blocks and plugs can be furnished to facilitate circuit testing, using portable instruments and meters. The current test block is arranged so that the current circuit is maintained when the plug is removed from the block.

Surge Protection

Every medium-voltage AC power system is subject to transient voltages in excess of normal operating voltages. There are many sources of transient voltages. The most prominent ones are

- Lightning
- Physical contact with a higher voltage system
- Resonant effects in series inductive-capacitive circuits
- Repetitive restrikes (intermittent grounds)
- Switching surges

To mitigate the effects of these transient voltages, both surge arresters and, where appropriate, surge capacitors should be used. Surge arresters limit the crest voltage of a voltage surge.

Surge capacitors reduce the steepness of the voltage wave which reaches the protected equipment. Surge capacitors, to be most effective, should be located as close to the protected equipment (usually motors) as possible with minimum inductance connections

ANSI DEVICE FUNCTIONS AND ACRONYMS

Table 4-4: ANSI Device Codes

Device	Function
1	Master element
2	Time delay starting or closing relay
3	Checking or interlocking relay
4	Master contactor
5	Stopping
6	Starting CIRCUIT BREAKER
7	Rate of CHANGE RELAY
8	Control power disconnecting device
9	Reversing device
10	Unit sequence switch
11	Multifunction device
12	Overspeed device
13	Synchronous-speed device
14	Underspeed device
15	Speed or frequency, matching device
16	Data communications device
17	Shunting or discharge switch
18	Accelerating or decelerating device
19	Starting to running transition contractor
20	Electrically operated valve
21	Distance relay
22	Equalizer circuit breaker
23	Temperature control device
24	Volts per Hertz relay
25	Synchronizing or synchronize-check device
26	Apparatus thermal device
27	Undervoltage relay

Device	Function
27s	DC undervoltage relay
28	Flame detector
29	Isolating contactor or switch
30	Annunciator relay
31	Separate excitation
32	Directional power relay or reverse power relay
33	Position switch
34	Master sequence device
35	Brush-operating or slip-ring short-circuiting device
36	Polarity or polarizing voltage devices
37	Undercurrent or underpower relay
38	Bearing protective device
39	Mechanical condition monitor
40	Field (over-/underexcitation) relay
41	Field circuit breaker
42	Running circuit breaker
43	Manual transfer or selector device
44	Unit sequence starting relay
45	DC overvoltage relay
46	Reverse-phase or phase-balance current relay
47	Phase-sequence or phase-balance voltage relay
48	Incomplete sequence relay
49	Machine or transformer, thermal relay-OLR
50	Instantaneous overcurrent relay
50G	Instantaneous earth over current relay (neutral CT method)
50N	Instantaneous earth over current relay (residual method)
50BF	Breaker failure
51	AC inverse time overcurrent relay
51LR	AC invers time overcurrent (locked rotor) protection Relay
51G	AC inverse time earth overcurrent relay (neutral CT method)
51N	AC inverse time earth overcurrent relay (residual method)
52	AC circuit breaker
52a	AC circuit breaker position (contact open when breaker open)
52b	AC circuit breaker position (contact closed when breaker open)
53	Exciter or DC generator relay
54	Turning gear engaging device
55	Power FACTOR RELAY
56	Field application relay
57	Short-circuiting or grounding device
58	Rectification failure relay
59	Overvoltage relay
60	Voltage or current balance relay
61	Density switch or sensor
62	Time-delay stopping or opening relay

Device	Function
63	Pressure switch
64	Ground detector relay
64REF	Restricted earth fault differential
64R	Rotor earth fault
64S	Stator earth fault
65	Governor
66	Notching or jogging device
67	AC directional overcurrent relay
67N	Directional earth fault relay
68	Blocking relay
69	Permissive control device
70	Rheostat
71	Liquid level switch
72	DC circuit breaker
73	Load-resistor contactor
74	Alarm relay
75	Position changing mechanism
76	DC overcurrent relay
77	Telemetering device
78	Phase-angle measuring relay or “out-of-step” relay
79	AC reclosing relay (auto-reclosing)
80	Flow switch
81	Frequency relay
82	DC reclosing relay
83	Automatic selective control or transfer relay
84	Operating mechanism
85	Communications, carrier or pilot-wire relay
86	Lockout relay/master trip
87	Differential protective relay
88	Auxiliary motor or motor generator
89	Line switch
90	Regulating device
91	Voltage directional relay
92	Voltage and power directional relay
93	Field changing contactor
94	Tripping or trip-free relay(trip circuit supervision relay)
95	For specific applications where other numbers are not suitable
96	Bus bar trip lockout relay
97	For specific applications where other numbers are not suitable
98	For specific applications where other numbers are not suitable
99	For specific applications where other numbers are not suitable
150	Earth fault indicator
AFD	Arc flash detector
CLK	Clock or timing source
DDR	Dynamic disturbance recorder
DFR	Digital fault recorder
DME	Disturbance monitor equipment

Device	Function
HIZ	High Impedance fault detector
HMI	Human machine interface
HST	Historian
LGC	Scheme logic
MET	Substation metering
PDC	Phasor data concentrator
PMU	Phasor measurement unit
PQM	Power quality monitor
RIO	Remote input/output device
RTU	Remote terminal unit/data concentrator
SER	Sequence of events recorder
TCM	Trip circuit monitor
LRSS	Local/remote selector switch
SOTF	Switch on to fault

SECTION 5. SECOGEAR SWITCHGEAR APPLICATIONS

This section covers typical circuit application packages for SecoGear metal-clad switchgear equipment.

The beginning of this section describes basic equipment for the protection, instrumentation, and control for each type of circuit. Ten standard applications are shown, including basic equipment and devices for commonly used configurations.

Then, front-view drawings demonstrate the allowable SecoVac and auxiliary compartment stacking combinations.

This section concludes with a sample lineup arrangement of breaker and VT locations. Devices illustrated in this section are assumed to utilize 125 Vdc control voltage.

To correctly utilize this section, follow these steps:

1. Determine the type and number of breaker circuits required, based on your one-line diagram.
2. Select the circuits that you will need from among the 10 basic circuit descriptions.
3. Choose any of the optional features of each circuit: protection, instrumentation, and control portion.
4. Determine the requirements for auxiliary compartments to house voltage transformers (VTs) or control power transformers (CPTs).
5. Determine the incoming and outgoing circuit conductor configurations required for each circuit.
6. Select the equipment configurations necessary for each circuit and auxiliary compartment. Refer to Figure 1-5 through Figure 1-26 covering breaker and auxiliary compartments.
7. Sketch your basic layout using the typical sections, accounting for all required breakers, VTs, CPTs, incoming connections, tie breakers or aux tie compartments, transition, and any utility metering or special sections.

Based on the breaker and auxiliary compartments and options selected, you can establish a structured lineup of metal-clad equipment. Some lineups, however, may require devices and circuit arrangements other than those included in this section. Contact your Sales Representative for more information on special configurations.

GLOSSARY: BASIC EQUIPMENT APPLICATIONS

A brief definition of each of the 10 basic equipment circuits is provided below.

General-purpose feeders

General-purpose feeder (GPF) equipment is a metal-clad circuit breaker and compartment, controlling and protecting a set of conductors supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two types of equipment. A general-purpose feeder includes circuit overcurrent protection, circuit current indication, and circuit control.

Transformer primary feeders

Transformer primary feeder (TPF) is similar to a general-purpose feeder except the entire load is one transformer and often includes differential protection for the entire circuit. Liquid filled transformers of an MVA rating to justify differential protection for the circuit are usually equipped with fault-pressure relays for additional internal protection. Both the differential and fault-pressure relays trip a hand-reset lockout relay, which trips the primary and secondary transformer circuit breakers.

Single-source incoming lines

Single source incoming line (SSIL) equipment is metalclad equipment for a main power distribution bus, with only one source of power supplying the bus. A system with this type of incoming line is called a radial system. A system with two or more incoming lines supplying distribution buses sectionalized by *normally open* bus-tie circuit breakers requires the same type of protection, instrumentation, and control as single source incoming lines, with the possible exception of the connection of the overcurrent relays.

Dual source incoming lines

Dual source incoming line (DSIL) equipment is metalclad equipment for a main power distribution bus with two sources of power supplying the main bus. One source is typically the normal source. The other source of power may be either another incoming line or a local generator. Both sources supply a common distribution bus with or without a *normally closed* bus-tie circuit breaker.

Bus ties

A bus tie (BT) is metal-clad equipment connecting two power distribution buses through a tie breaker. Such equipment often is not equipped with overcurrent relays because of the difficulty of obtaining selective system operation with bus-tie overcurrent relays. A bus tie requires two compartments in adjacent sections; see available arrangements later in this section (Figure 5-5).

Bus entrances

A bus entrance (BE) is a metal-clad vertical section in which one of the compartments contains incoming conductors (cable or bus duct) which are connected directly to the main bus (also referred to as a cable tap). No incoming breaker is used. This arrangement applies to lineups of switchgear, without main circuit breakers, which connect the incoming line directly to the main bus. It also applies to subfeeds from a lineup of switchgear without circuit breakers, connecting the outgoing conductors to the main bus.

Induction motor feeders, full-voltage start

Induction motor feeder (IMF) is similar to a general-purpose feeder, except it is used for controlling and protecting full-voltage-start motors and is designated as motor "branch circuit" protective equipment. For motors greater than 1500 HP, motor differential protection is typically required.

Motor feeders, reduced-voltage start

Reduced-voltage-start applications, utilizing reactors or autotransformers, are available. Contact your Sales Representative for additional information.

Synchronous motor feeders, full-voltage start

Synchronous motor feeder (SMF) is similar to an induction motor feeder, except it is used for controlling and protecting full-voltage-start synchronous motors and is designated as motor "branch circuit" protective equipment. For motors greater than 1500 HP, motor differential protection is typically required.

Future unit

The metal-clad future unit (FU) compartments are a basic mechanically prepared circuit breaker unit, except the breaker is to be provided at a future date. Provisions are made to receive a breaker of specified rating. It is recommended to equip these base units with the breaker stationary auxiliary switch and breaker position switch, if the active feeders are so equipped, and install current transformers (possibly multiratio). This minimizes field installation, downtime and adjustment procedures when the application of this base unit is determined. The selected relays may be added to the door when the circuit application is determined, or a new door may be purchased with relays and devices completely wired.

GENERAL-PURPOSE FEEDERS (GPF)

A general-purpose feeder (GPF) is metal-clad equipment controlling and protecting a set of conductors supplying one or more branch circuit distribution centers, one or more branch circuit distribution centers, or any combination of these centers.

Protective Scheme Selection

- GPF-1: Use this type of feeder for systems that are impedance or solidly grounded and for which selectivity is not required with downstream residually connected ground relays.

  GPF-1 feeders include three-phase overcurrent protection (50/51) and one instantaneous overcurrent element (50GS) connected to a ground-sensor CT (GSCT).

- GPF-2: Use this type of feeder for systems that are impedance or solidly grounded and for which selectivity is required with downstream residually connected ground relays.

  GPF-2 feeders include three-phase overcurrent protection (50/51) and residually connected time over current ground element (51N).

- GPF-3: Use this type of feeder for ungrounded or solidly grounded systems for which no ground relays are desired.

  GPF-3 feeders include three-phase overcurrent protection (50/51) and no ground fault element.

Optional Equipment Selection

Protection

- **Automatic Reclosing**: For open-wire overhead distribution circuits on which this feature is desired, use the MIF II, F650 or 850 relay, which includes automatic-reclosing (79) and cutoff switch (79CO) functionality.

Current Transformers for Differential Circuits

For a feeder included in a bus-differential-protected zone, add a separate set of three current transformers located on the outgoing side of the feeder.

For a transformer-differential-protected zone, add a separate set of three current transformers located so that the feeder circuit breaker is included in the zone.

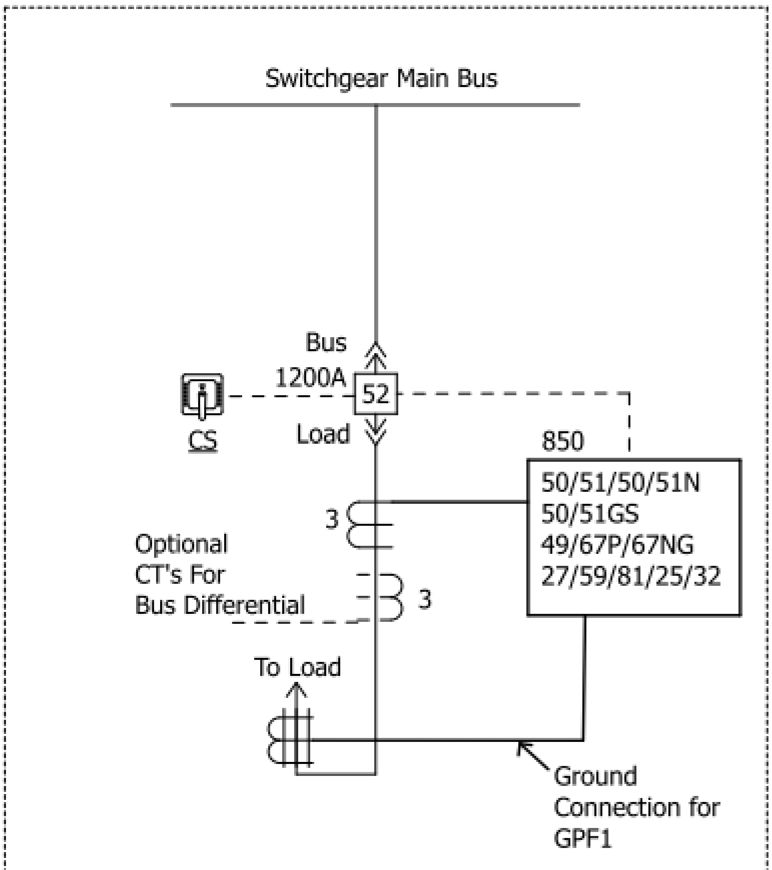
Indication

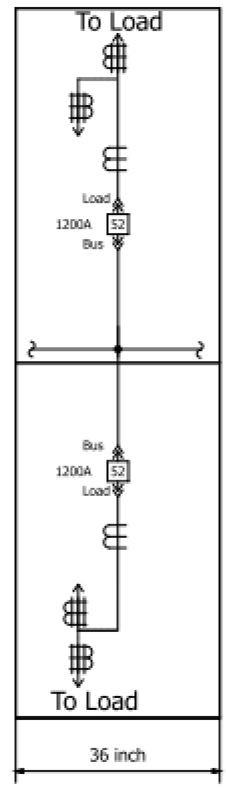
- **Instrumentation and Metering**: Most solid-state protective relays today offer basic load current indication (such as 350). Some relays include extensive metering functions such as Amps, Volts, Watts, Vars, PF, and demand functions (such as 850, F650, F35 &, F60, 3 Series, 8 Series, UR family)
- **Test Blocks**: For circuits that require the provisions for insertion of portable recording meters or other similar devices, add current and voltage test blocks. The basic current test block is wired to maintain the circuit when the test plug is removed.
- **Indicating Lamp**: Additional indicating lamps can be provided, such as for circuits requiring a circuit breaker disagreement or spring-charged indication function.

Control

- Control Voltage: Available control voltages are 48 Vdc, 125 Vdc, 250 Vdc, 120 Vac, and 240 Vac. For AC control, if a reliable 120 Vac/240 Vac source is not available at the site, then include a control power transformer connected to each incoming line in each lineup, plus an autocharged, capacitor-trip device for each circuit breaker in the lineup.
- Remote Control: For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 4-1. From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "test/disconnect" position and local trip with the breaker in the "connect" or "test/disconnect" position.

Figure 5-1: General-Purpose Feeder





TRANSFORMER PRIMARY FEEDERS (TPF)

A transformer primary feeder is similar to a general-purpose feeder, except the entire load is one transformer and the circuit is typically protected with transformer differential relays. If transformer differential protection is not required, use a general-purpose feeder.

Protective Scheme Selection

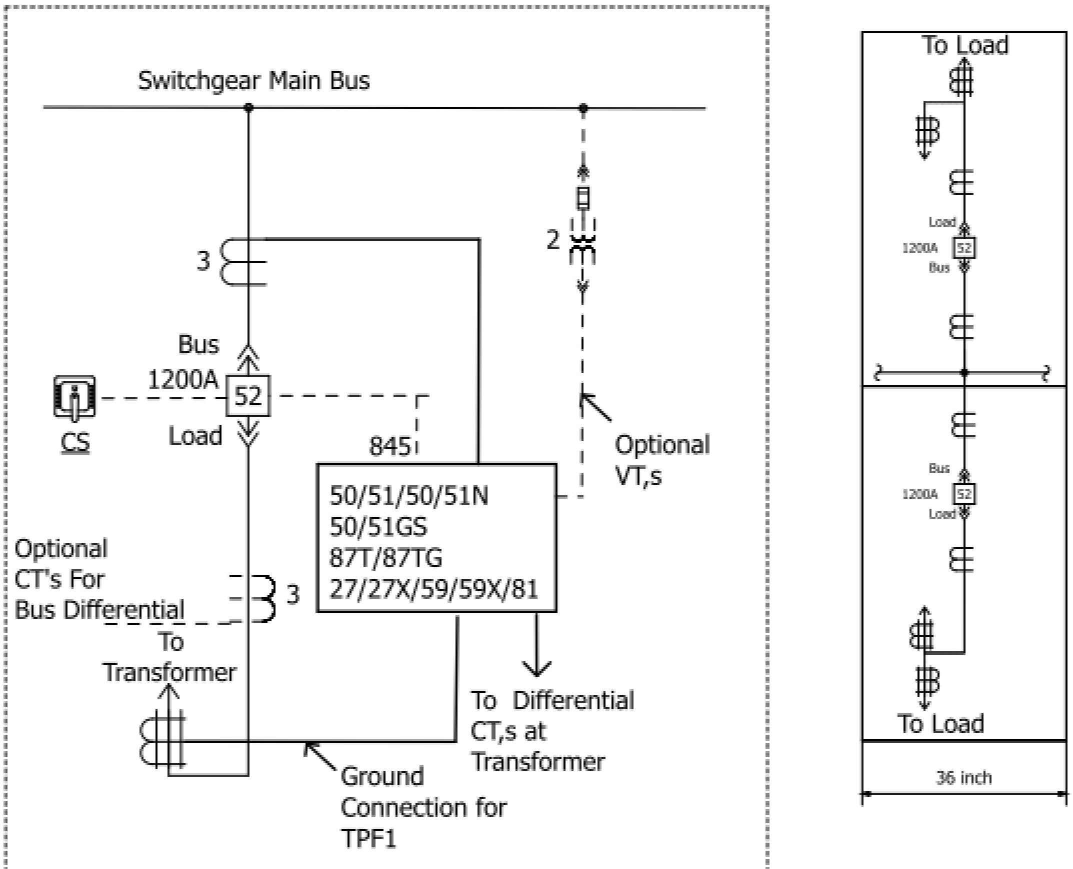
Basic devices included in a transformer primary feeder are the same as those included in a general-purpose feeder plus three additional current transformers for the differential protection, a transformer fault-pressure auxiliary relay (63PX) and a Series 95 lockout relay (86T).

Differential protection can be in the form of separate relays, such as Type STD single-phase transformer differential relays (87T), or as part of a complete multifunction transformer protection package, like relays 845, T35, or T60.

Optional Equipment Selection

Options for a transformer primary feeder are the same as for a general-purpose feeder, except that automatic reclosing is not used. Select options for TPF-1, TPF-2, or TPF-3 on the same basis as for GPF-1, GPF-2, or GPF-3 (see GPF “Protective Scheme Selection,” above).

Figure 5-2: Transformer Primary Feeder



SINGLE-SOURCE INCOMING LINES (SSIL), OR DUAL SOURCE WITH NORMALLY OPEN TIE BREAKERS

A single source incoming line is a metal-clad section containing a power circuit breaker acting as the main disconnect between a main power distribution bus and the only source of power supplying the bus.

A system with two or more incoming lines, with supply distribution buses sectionalized by normally open bus-tie breakers, requires essentially the same type of protection, instrumentation, and control for each incoming line as a single source incoming line.

Protective Scheme Selection

- SSIL-1: Use this type of incoming line for an impedance or solidly grounded system fed from a local wye-connected transformer with a current transformer in the transformer neutral connection.

  This type of incoming line would include three-phase time-over-current protection (51) and a ground-overcurrent element (51G) to be connected to the neutral current transformer of a local power transformer feeding the incoming line.

- **SSIL-2**: Use this type of incoming line for an impedance or solidly grounded system fed from a remote wye-connected transformer, or a local wye-connected transformer with no current transformer in the transformer neutral connection.

  This type of incoming line would include three-phase time-overcurrent protection (51) and residually connected ground-over-current relay (51N).

- **SSIL-3**: Use this type of incoming line for ungrounded or solidly grounded systems for which no ground relays are desired.

  This type of incoming line would include three-phase time-overcurrent protection (51), and no ground relays.

Optional Equipment Selection

Protection

- **Overcurrent Relay Characteristics**: Time-current characteristics for overcurrent relays are determined by system studies. After the time-current characteristic has been established, ensure the relays selected offer the required time current characteristics that satisfy the application.
- **Current Summation Connection**: For lineups containing bus-tie breakers, specify that the incoming line overcurrent relays be wired for current summation (also known as partial differential). Add a lockout relay (86) and a set of three CTs, mounted on the tie breaker, for each set of relays to be wired this way.
- **Open-phase Protection**: For incoming lines fed from transformers with fused primaries or sources subject to single-phase operation, add negative-sequence voltage protection (60/47) and time delay (62). This function is available in multifunction relay protection packages, such as Type 850 and F650, or as a single function relay Type NBV or other.
- **Transformer Differential Protection**: Add differential protection for incoming lines fed from transformers with a means to trip a primary breaker. Differential protection can be in the form of separate relays, such as Type STD single-phase transformer differential relays (87T), or as part of a complete multifunction transformer protection package, like 845, T35 or T60 relays. In addition, add one Type Series 95 lockout relay (86T), one Type HAA fault pressure auxiliary target relay
(63FPX), and a set of three current transformers.
For impedance grounded systems with larger transformers and for which three-phase transformer differential relaying is not sensitive enough to detect secondary ground faults, include ground differential relay protection (87TG) with a single function Type IFD relay, or as part of a complete multifunction transformer protection package.
- **Bus Differential Protection**: For systems requiring bus differential protection, add a B30 or B90 three-phase solid state differential protection relay (87B) and one Type Series 95 hand reset lockout relay (86B). Bus differential requires a dedicated set of three CTs on the incoming line.
- **Current Transformers for Remotely Located Differential Relays**: For incoming lines included in bus or transformer differential zones for which relays are not mounted on the incoming line equipment, add a separate set of three current transformers for each differential function.
- **Directional Power, Underfrequency, and Undervoltage Protection**: To detect utility tie circuit fault conditions prior to automatic reclosing and to initiate programmed load shedding, add, either singly or in combination, a power directional relay (32), underfrequency relay (81), undervoltge relay (27) and timer (62). This applies for systems with local generation or large motors. These features are included in Multilin 850 and F650 relays. A study of each system is required to assure proper selection and circuit location of these relays.
- **Automatic Throwover**: For lineups with a normally open tie breaker or a normally open alternate incoming line breaker, add automatic primary throwover equipment if desired. This consists of two undervoltage relays (27), two multicontact auxiliary relays (27X), two timers (2 and 62), two auxiliary relays (2X and 62X), and one manual-automatic selector switch (43).
Automatic throwover equipment requires an empty auxiliary compartment for mounting, custom designed for each application. If using 850 multifunction relays on the incoming line and tie breakers, only two timers (2 and 62), two auxiliary relays (2X and 62X), and one manual-automatic switch (43) are required.

Indication

- **Instrumentation and Metering**: For incoming lines for which voltage indication and relay voltage source are not required, omit the voltmeter, voltmeter switch, and two voltage transformers. For circuits requiring the indication or metering of additional electrical quantities, add indicating analog meters as appropriate or a multifunction meter, such as EPM6000. Some relays include extensive metering functions such as Amps, Volts, Watts, Vars, PF and demand functions (such as 850 & F650).

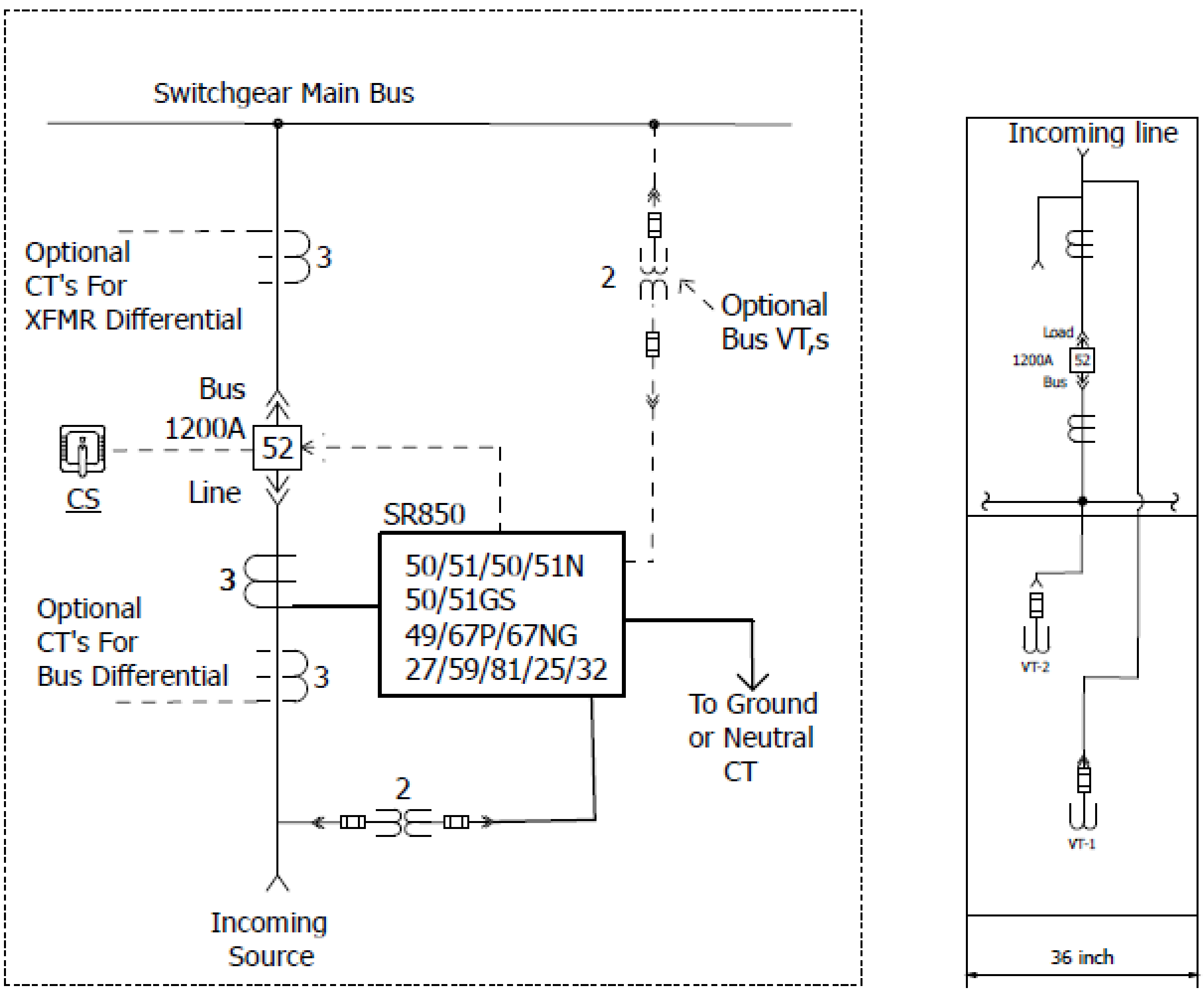
- Test Blocks: For circuits that require the provisions for insertion of portable recording meters or other similar devices, add current and voltage test block. Basic test block is wired to maintain the circuit when the test plug is removed.
- Indicating Lamp: Additional indicating lamps can be provided, such as for circuits requiring a circuit breaker disagreement or spring-charged indication function.

Control

- Control Voltage: Available control voltages are 48 Vdc, 125 Vdc, 250 Vdc, 120 Vac and 240 Vac. For AC control, if a reliable 120 Vac/240 Vac source is not available at the site, then include a control power transformer connected to each incoming line in each lineup, plus an auto-charged, capacitor-trip device for each circuit breaker and each lockout relay (86) in the lineup. For dual sources with normally open-tie circuit breaker and AC control, add CPT throwover contactor.
- Remote Control: For circuit breakers controlled from a remote location, choose the remote control scheme for those listed in Table 4-1. From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the “connect” position; local close with the breaker in the “test/disconnect” position; and local trip with the breaker in the “connect” or “test/disconnect” position.

If several optional devices are added to an incoming line section, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie-breaker vertical section or on an adjacent auxiliary compartment.

Figure 5-3: Single-source Incoming Line



DUAL-SOURCE INCOMING LINES (DSIL)

Dual source incoming line equipment (DSIL) is a metalclad section containing a power circuit breaker acting as a main disconnect between a main power distribution bus and one of two sources of power supplying the main bus. The other source of power may be either another incoming line or a local generator. Both sources supply a common distribution bus, with or without a normally closed bus-tie breaker.

Basic Equipment Selection

- DSIL-1: Use this type of incoming line for an impedance or solidly grounded system fed from a local wye-connected power transformer, with a current transformer in the transformer neutral connection.
  This type of incoming line equipment includes three-phase overcurrent relays (51) and three-directional phase-overcurrent relays (67). It includes one ground-over-current relay, (51G) connected to the neutral CT of a local power transformer feeding the incoming line and one residually connected directional ground-overcurrent relay (67N), polarized from the power transformer neutral CT. These protective functions are available in a single relay package, such as the 850, F650 or F60 relays.
- DSIL-2: Use this type of incoming line for an impedance or solidly grounded system fed from a remote wye-connected power transformer.
  This type of incoming line equipment includes three-phase overcurrent (51) and directional phase-overcurrent (67). It also includes residual-connected ground-overcurrent (51G) and residually connected directional ground-overcurrent (67N) polarized from a wye-broken delta auxiliary VT connected to a set of wye-wye VTs. These protective functions are available in a single relay package, such as the 850, F650 or F60 relays.
- DSIL-3: Use this type of incoming line for ungrounded systems only.
  This type of incoming line equipment includes three phase-overcurrent (51) and directional phase-overcurrent relays (67), no ground fault detection. These protective functions are available in a single relay package, such as the 850, F650 or F60 relays. There are additional functions available as required.

Optional Equipment Selection

Protection

- Overcurrent Relay Characteristics: Time-current characteristics for overcurrent relays are determined by system studies. After the time-current characteristic has been established, make sure the relays selected offer the required time current characteristics that satisfy the application.
- OPEN-PHASE PROTECTION: For incoming lines fed from transformers with fused primaries or sources subject to single-phase operation, add negative-sequence voltage protection (60) and timer (62), as well as current-balance detection (60C), to distinguish which incoming line has single-phase operation.
- Transformer and Bus Differential Protection: Add relays and current transformers to obtain this protection, using the same considerations as for single source incoming lines.
- Directional Power, Underfrequency, and Undervoltage Protection: Add separate relays or enable these functions in multifunction relays to obtain this protection using the same considerations as for single-source incoming lines.

Indication

- Instrumentation and Metering: For circuits requiring the indication or metering of additional electrical quantities, add indicating analog meters as appropriate or a multifunction meter such as Type EPM 6000. Some relays also include extensive metering functions such as Amps, Volts, Watts, Vars, PF, and demand functions (such as 850 &, F650).
- Test Blocks: For circuits that require provisions for insertion of portable recording meters or other similar devices, add a current and voltage test block. Basic test block is wired to maintain the circuit when the test plug is removed.
- Indicating Lamp: Additional indicating lamps can be provided, such as for circuits requiring a circuit breaker disagreement or spring-charged indication function.

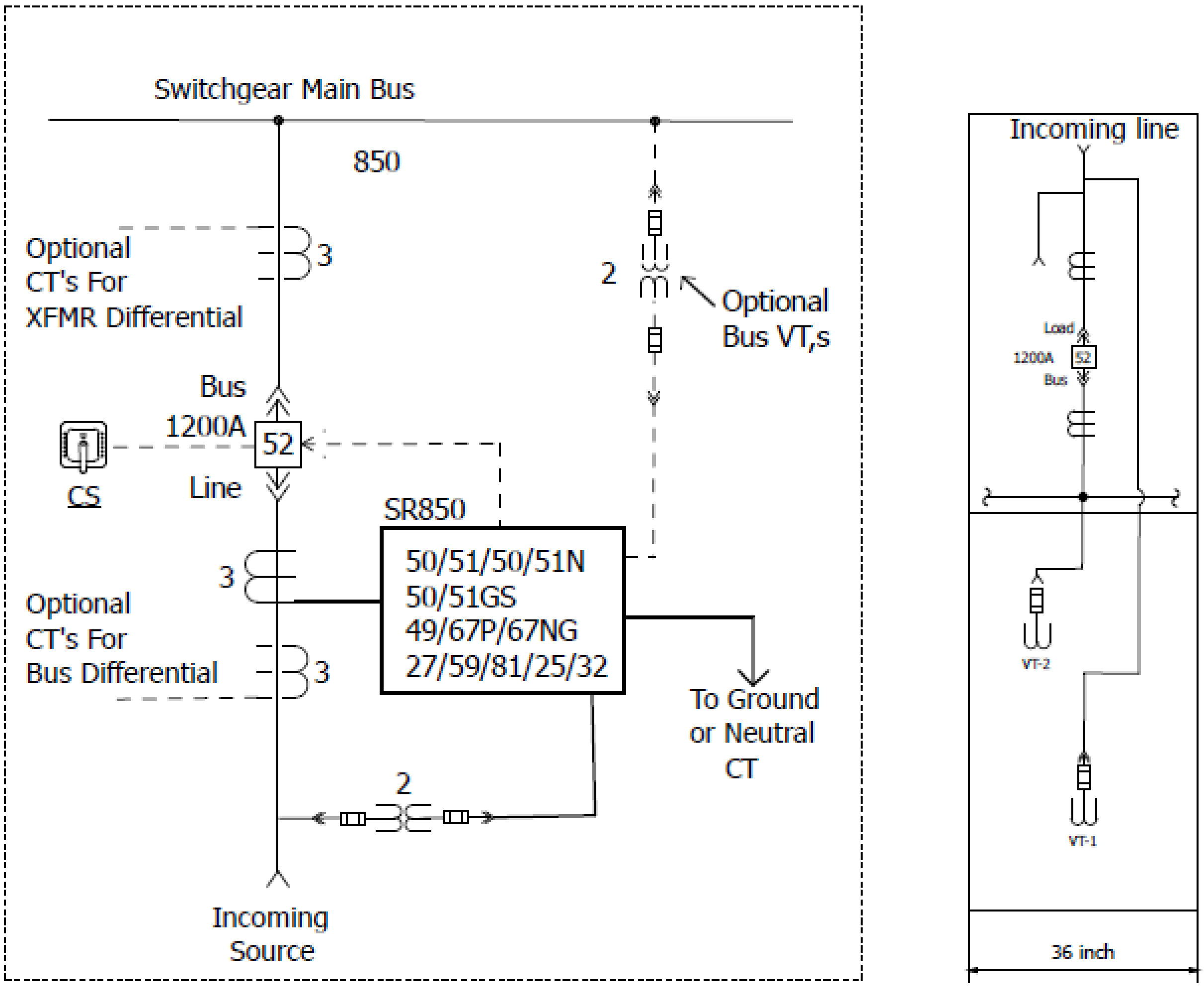
Control

Optional features involving control voltage and permissive control switch are the same as for single-source incoming line equipment.

Location of Optional Devices

If several optional devices are added to incoming line equipment, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie breaker vertical section, or on an adjacent auxiliary compartment.

Figure 5-4: Dual-Source Incoming Line



BUS TIES (BT)

A bus tie is metal-clad equipment connecting two power distributions buses through a tie breaker. Such equipment is sometimes specified without overcurrent relays because of the difficulty of obtaining selective system operation when using bus-tie overcurrent relays.

Basic Equipment Selection

Basic bus-tie circuit breaker and auxiliary bus are located in the bottom compartment of each of two vertical sections.

The top compartment of either or both vertical sections can be used as either an auxiliary compartment or a feeder compartment. See Figure 5-5 for arrangement restrictions when selecting bus tie equipment. The basic equipment included in a bus tie is a circuit breaker control switch and indicating lights.

Optional Equipment Selection

Protection

- Overcurrent Protection: For systems requiring overcurrent protection relays for bus-tie equipment, specify incoming line overcurrent relay(s) (50/51) to be wired for a summation current connection. If residually connected ground-over-current relays (51N) are required with an incoming line, the equipment may be wired also for a summation current connection. Include a second set of three current transformers if your system has a second incoming line.
- Bus-Differential Protection: For systems requiring bus-differential protection, relays can be mounted in bus-tie vertical sections. Each set of bus-differential protection includes three-phase high-speed bus-differential relays (87B) such as Multilin B30 or B90, one Type Series 95 hand-reset lockout relay (86B), and three current transformers. If the bus-differential relays have been included in the incoming line (SSIL or DSIL) package, then additional relays are not required.

- **Automatic Throwover**: For systems with a normally open bus-tie circuit breaker that require automatic throwover, add equipment listed under SSIL “Optional Equipment Selection” in an auxiliary compartment above one of the bus-tie compartments.

  The control panel for automatic throwover of CPTs can be placed on a swinging auxiliary panel, above a bus-tie, behind the front door of an auxiliary compartment.

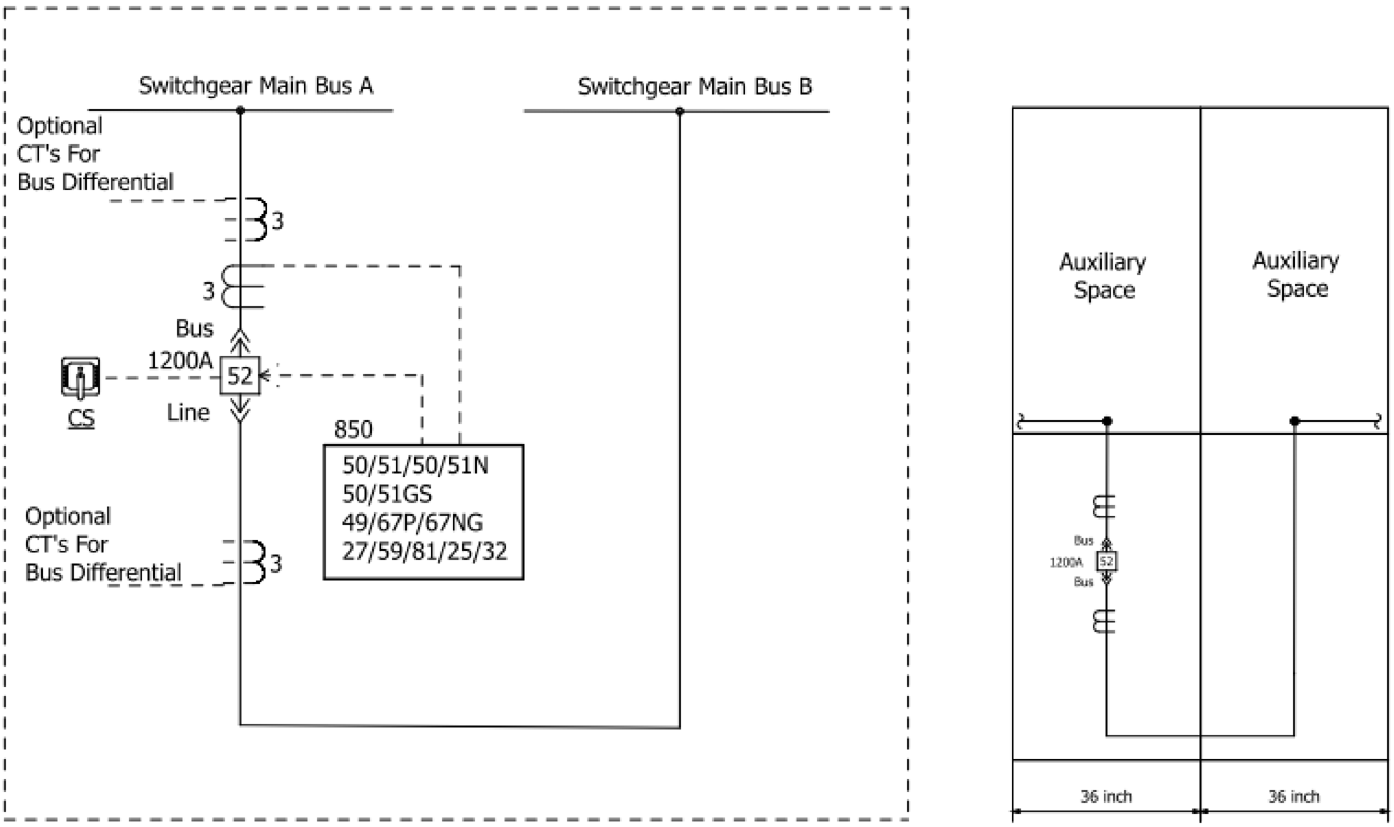
Indication

- **Instrumentation**: For indication of current, add three current transformers (if no CTs are present for overcurrent relaying), an ammeter, and an ammeter switch, or a digital three-phase ammeter.
- **Test Blocks**: For circuits that require the provisions for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.
- **Indicating Lamp**: Additional indicating lamps can be provided, such as for circuits requiring a circuit breaker disagreement or spring-charged indication function.

Control

Optional features involving control voltage and a permissive control switch are the same as for single source incoming line equipment. For circuit breakers where AC control is specified, include a secondary automatic-throwover contactor for control power.

Figure 5-5: Bus Tie



BUS ENTRANCES (BE)

Bus entrance equipment, also referred to as a cable tap, is a metal-clad vertical section in which one of the compartments contains incoming or outgoing conductors connecting directly to the main bus without the use of a circuit breaker. Conductors can be either cables or non-seg bus duct.

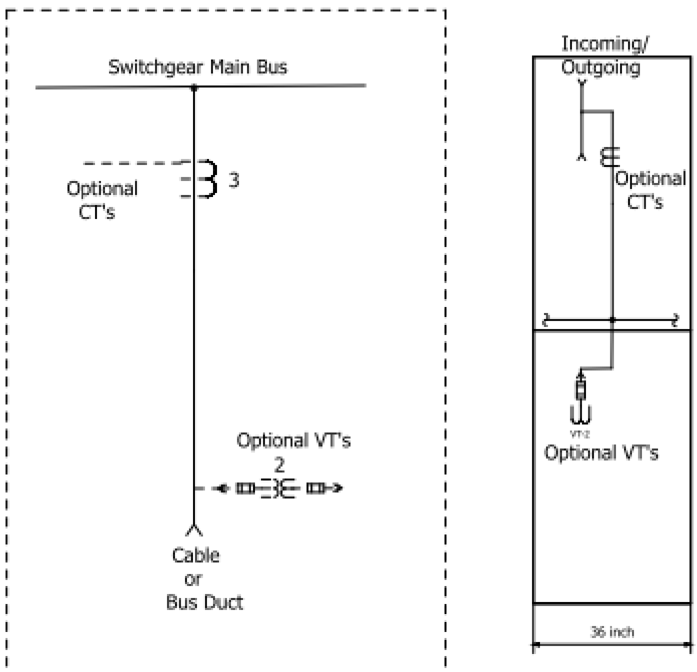
Basic Equipment Selection

Select this type of equipment as a means to connect either incoming or outgoing conductors directly to the bus for circuits that require no circuit breakers. See “SECTION 1” and Figure 5-6 for configuration restrictions when selecting bus entrances.

Optional Indication Selection

- **Instrumentation and Metering**: For circuits requiring indication or metering of electrical quantities, add three current transformers or two voltage transformers. If you cannot locate both a set of CTs and VTs in a bus entrance, select instrumentation and metering required as necessary.
- **Test Blocks**: For circuits requiring provisions for insertion of portable recording meters or other similar devices, add current and voltage test blocks. A basic current block is wired to maintain the circuit when the test plug is removed.

Figure 5-6: Bus Entrance



INDUCTION MOTOR FEEDERS (IMF)

Induction motor feeders are used to control and protect full-voltage-start motors and are designated as “branch circuit” protective equipment. Economics usually preclude protecting a motor smaller than 1500 HP (IMF1) with a device package as complete as one used for larger motors (IMF2).

The equipment is specified for use on impedance grounded or solidly grounded systems. See “Optional Equipment Selection (for IMFE, IMF1, IMF2)” for modifications of this equipment for use on systems with other types of grounding. Also see IEEE C37.96-2000 IEEE Guide for AC Motor Protection for relaying recommendations.

Protective Scheme Selection

- **IMF1**: Basic equipment for IMF1 includes three-phase running overload, locked rotor, and short-circuit protection (49/50); undervoltage protection with time delay (27, 62 – only one per lineup required); zero-sequence ground-fault protection (50GS); and load current indication. The overcurrent relays operate from three CTs, one in each phase, and a ground-sensor CT. Complete economical motor protection packages are available in Multilin 339 digital motor protection relays. For undervoltage protection when using Multilin 339, add a separate Multilin MIV undervoltage relay. When using Multilin 339, specify the optional MPM module, or add a separate MIV relay as noted above.

- **IMF2**: Basic equipment for IMF2 is Multilin 869 digital motor protection relay, which includes (26/50/83) for locked rotor and short-circuit protection; overtemperature (49); undervoltage with time delay (27, 62); 3-phase self-balancing machine differential (87M); one Type Series 95 lockout relay (86M); zero-sequence ground fault (50GS); and full function metering. Additional protective functions are available in the 869. Multilin relay 869 operates from three current transformers, one in each phase, a ground sensor CT, and three current transformers located at the motor.
- **IMFE**: Metal-clad feeder equipment (IMFE) is used for controlling and protecting full-voltage-start, essential service motors and is designated as motor "branch circuit" protective equipment. Such motor feeders sound an alarm only for motor overload, but trip the circuit breaker for locked rotor and short-circuit conditions. Basic equipment for IMFE includes a Multilin 339 digital motor protection relay, which provides three-phase overload indication, locked-rotor tripping, short-circuit tripping (49/50/83), zero-sequence ground-fault protection, and load current indication. No undervoltage protection is included. Multilin relay 339 operates from three current transformers, one in each phase, and a ground sensor CT.

Optional Equipment Selection (for IMFE, IMF1, IMF2)

Protection

For ungrounded systems, omit the ground-sensor overcurrent relay and the current transformer. When equipment is used to feed more than one motor from the same bus, only one Multilin MIV undervoltage relay is required. However, for multiple motors, add auxiliary relays (27X), with sufficient contacts to trip each additional motor feeder breaker.

For both smaller and larger motors (greater than 1500 HP), complete protection including motor differential can be obtained by using the Multilin 869 relay (with motor mounted CTs). The CTs located at the motor and used for the motor differential (87M) circuit are typically furnished by the motor manufacturer. They are not supplied with the switchgear.

For lineups with bus differential protection, add three current transformers. For motors with RTDs, the Multilin 869, 369, and 339 digital motor protection relays offer RTD sensing inputs.

Indication

- **Instrumentation and Metering**: For circuits requiring the indication or metering of additional electrical quantities, and using Multilin 369 or 869 relays. For circuits without metering built into the multifunction protective relay, add a PQM II power quality meter, which includes indication of all three phases of current, in addition to Volts, Watts, Vars, PF, and demand functions.
- **Test Blocks**: For circuits that require the provisions for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current test blocks are wired to maintain the circuit when the test plug is removed.
- **Indicating Lamp**: For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

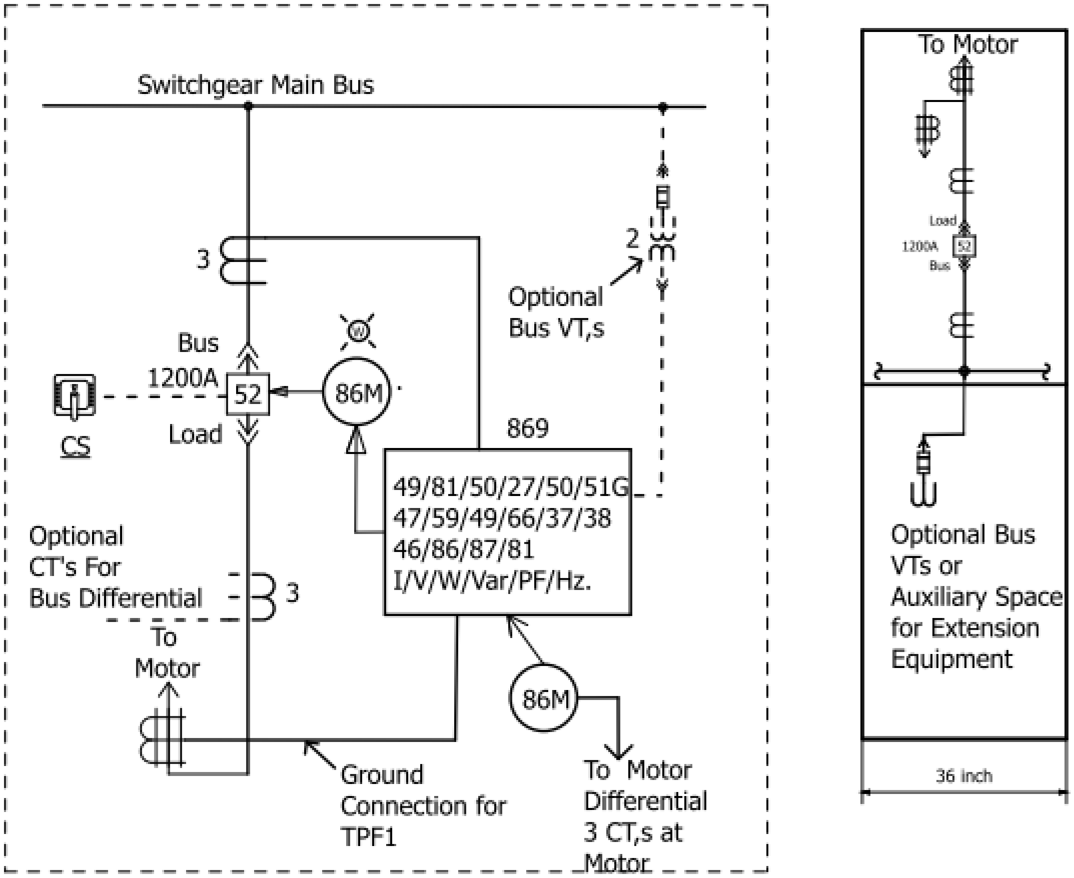
- **Remote Control**; For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 4-1. From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

  In addition, remote control for motors requires a lockout relay (86) in order to prevent breakers' closing (after a relay-initiated trip) until the lockout device is manually reset. (The 86 device specified on IMF2 may be used for both 87M and remote control.)

Location of Optional Devices

If several optional devices are added to motor feeder equipment, there may not be sufficient space to mount them all. In this case, specify that the excess relays are to be mounted on an adjacent auxiliary compartment. This makes the vertical section a custom section.

Figure 5-7: Induction Motor Feeder



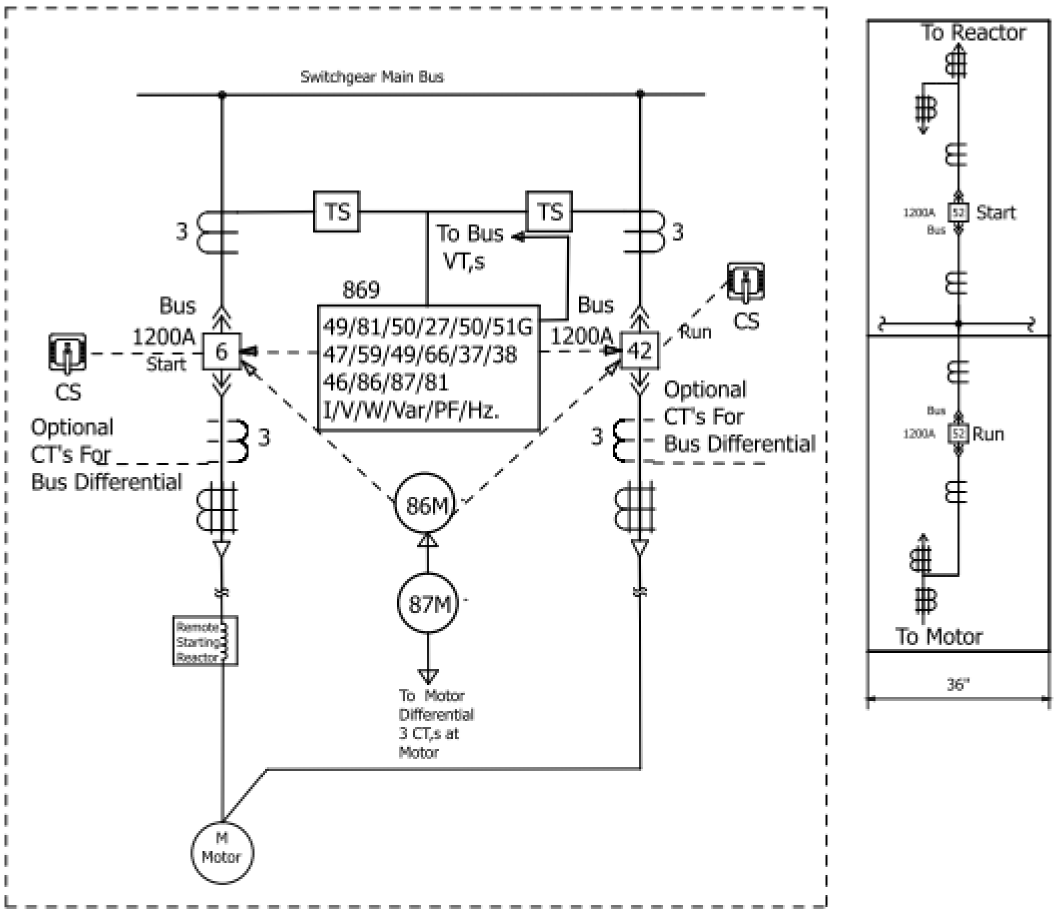
REDUCED VOLTAGE STARTING

Power distribution system voltage regulation requirements sometimes mandate reduced current starting to minimize the current inrush and voltage sag when starting large motors.

Inserting a reactor and then bypassing it as the motor comes up to speed is one method of accomplishing this objective.

An auto transformer connection is an alternate method of reduced voltage starting. This method applies a reduced voltage via the autotransformer, which is shorted out as the motor comes up to speed. Figure 5-8 through Figure 5-9 illustrate the typical SecoGear circuits and arrangements for these special motor starting requirements.

Figure 5-8: Reduced Voltage Reactor Start



SYNCHRONOUS MOTOR FEEDERS (SMF)

Synchronous motor feeders are used to control and protect full-voltage-start synchronous motors and are designated as motor "branch circuit" protective equipment. Economics usually preclude protecting a motor smaller than 1500 HP (SMF1) with a device package as complete as one used for larger motors (SMF2). Also see IEEE C37.96-2012 IEEE Guide for AC Motor Protection for relaying recommendations.

Protective Scheme Selection

- SMF1: Basic equipment for an SMF-1 (1500 HP and less) includes three-phase running overload, locked rotor, and short-circuit protection (49/50); undervoltage protection with time delay (27, 62) (only one required per lineup); zero sequence ground-fault protection (50GS); load current indication. The overcurrent relays operate from three CTs, one in each phase, and a ground-sensor CT.

  A complete economical motor protection package is available in the Multilin 869 digital motor protection relay. The equipment is specified for use on impedance grounded or solidly grounded systems. See "Optional Equipment Selection (for SMF1 and SMF2)" for modifications of this equipment for use on systems with other types of grounding or having motors with other types of excitation.
- SMF2: Basic equipment for an SMF2 (greater than 1500 HP) is a Multilin 869 digital motor protection relay, which includes three-phase running overload, locked rotor, and short-circuit protection (49/50); undervoltage

protection with time delay (27, 62 – only one required per lineup); three-phase self-balancing machine differential (87M); one Type Series 95 lockout relay (86M); zero-sequence ground fault (50GS); and full function metering.

Additional protective functions are available in the 869. The Multilin 869 relay operates from three current transformers, one in each phase, a ground sensor CT, and three current transformers located at the motor.

Optional Equipment Selection (for SMF1 and SMF2)

Protection

If six-CT machine differential relaying (87M) is required, use Multilin relay 869 and six CTs (three in machine neutral leads and three in metal-clad switchgear). Specify that the 869 relay be wired for current summation differential in lieu of self-balance.

For starting control, synchronization and enhanced protection in collector-ring and brushless type motors, add the Multilin SPM relay. For ungrounded systems, omit the ground sensor overcurrent relay (50GS) and the current transformer.

When equipment is used to feed more than one motor from the same bus, only one Multilin MIV undervoltage relay is required. However, for multiple motors, add auxiliary relays (27X), with sufficient contacts to trip each additional motor feeder breaker.

For both smaller motors and larger motors (greater than 1500HP), complete protection including motor differential can be obtained by using the Multilin 869 relay (with motor mounted CTs).

Excitation

Field application equipment or exciter packages for a synchronous motor are typically furnished with the motor package. Excitation packages and panels can be sourced and mounted in a switchgear compartment or section.

These application panels are considered custom design.

Indication

- **Instrumentation and Metering**: Multilin 869 provides extensive metering capabilities. For circuits requiring additional or separate metering, add a PQM II power quality meter, which includes indication of all three phases of load current, in addition to Volts, Watts, Vars, PF, and demand functions.
- **Test Blocks**: For circuits that require provisions for insertion of portable recording meters or other similar devices, add current and voltage test blocks. The basic current test block is wired to maintain the circuit when the test plug is removed.
- **Indicating Lamp**: For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

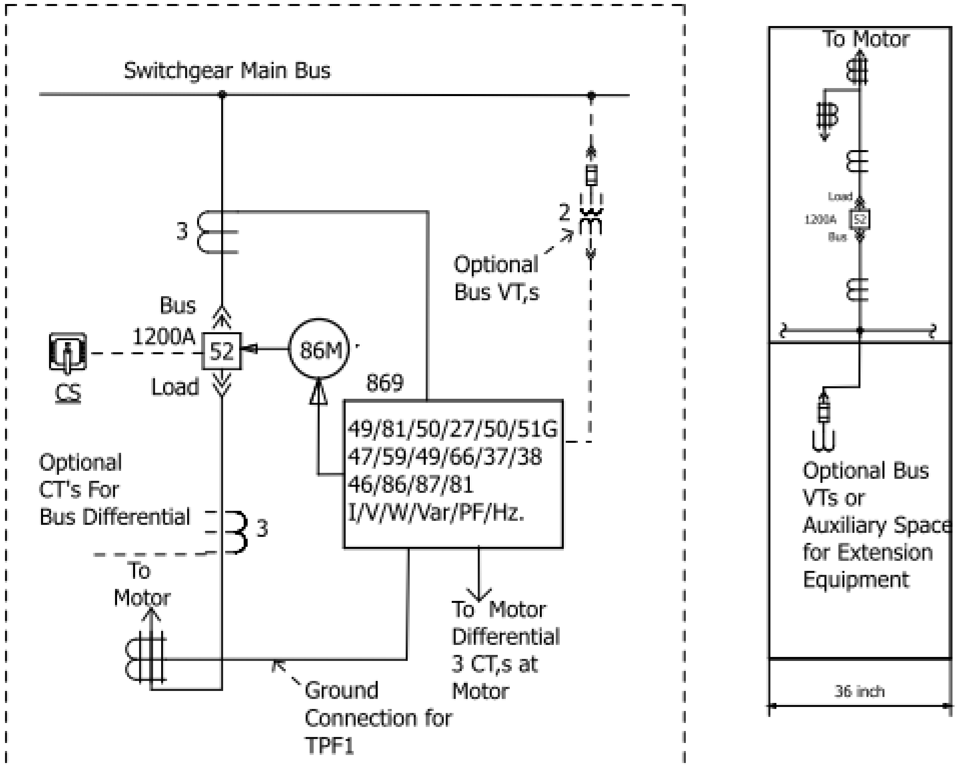
- **Remote Control**: For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 4-1. From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C. remote close and trip is possible only with the breaker in the “connected” position; local close with the breaker in the “test” position; and local trip with the breaker in the “connected” or “test” position.

  In addition, remote control for motors requires a lockout relay (86), which prevents breaker closing (after a relay-initiated trip) until the lockout device is manually reset. (The 86 device specified on SMF2 may be used for both 87M and remote control.)

Location of Optional Devices

If several optional devices are added to motor feeder equipment, there may not be sufficient space to mount them all. In this case, specify that the excess relays are to be mounted on an adjacent auxiliary compartment. This makes the vertical section a custom section.

Figure 5-9: Synchronous Motor Feeder



STANDARD BREAKER AND AUXILIARY CONFIGURATIONS

Figure 5-10: Sample Lineup – A

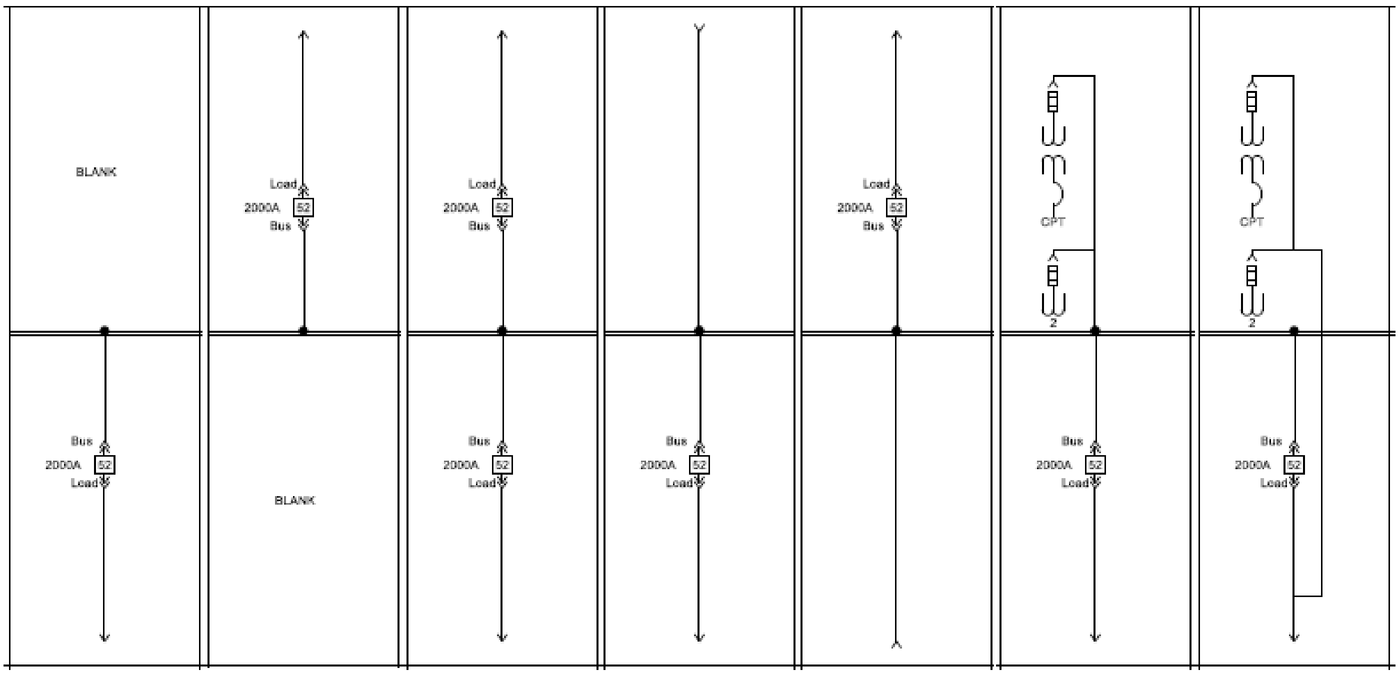
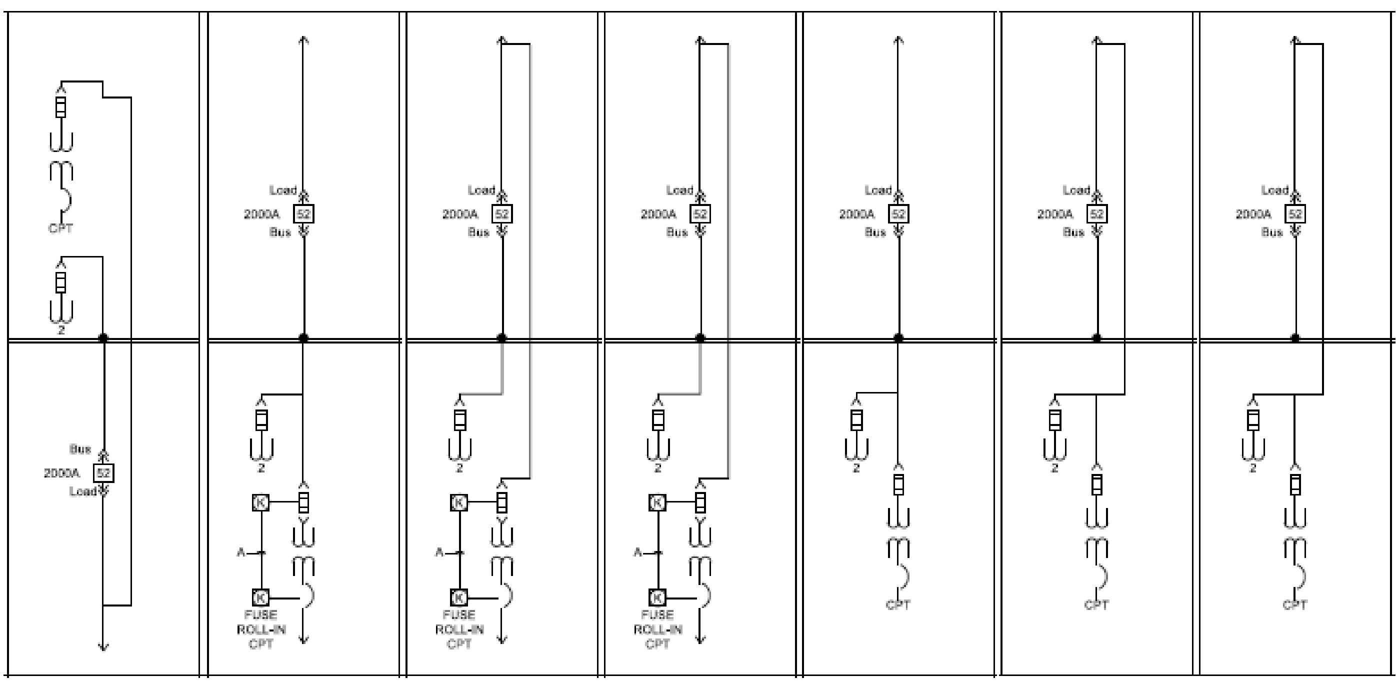


Figure 5-11: Sample Lineup – B



STANDARD TIE BREAKER AND AUXILIARY CONFIGURATIONS

Figure 5-12: Tie Breaker and Aux Tie Stack

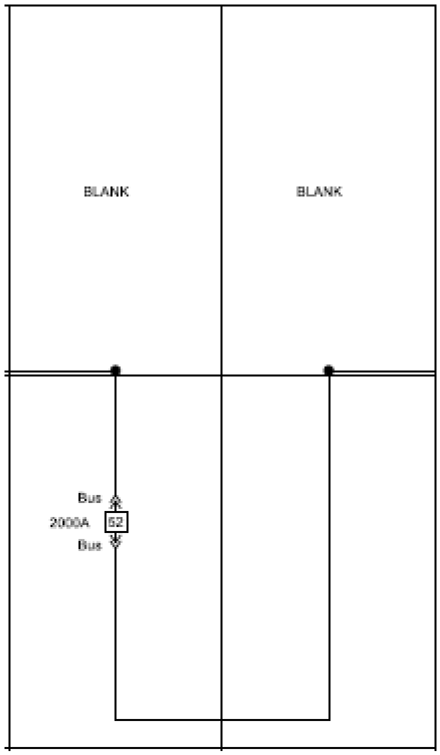


Figure 5-14: Feeder Breakers in Upper Compartment

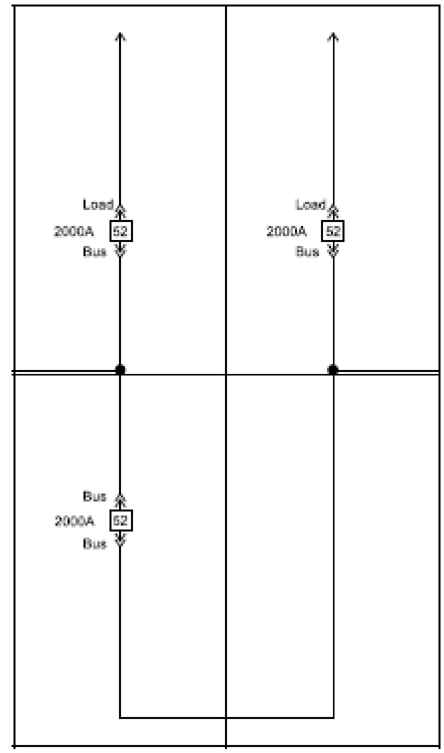


Figure 5-13: Bus VTs on Each Side of Tie Breaker

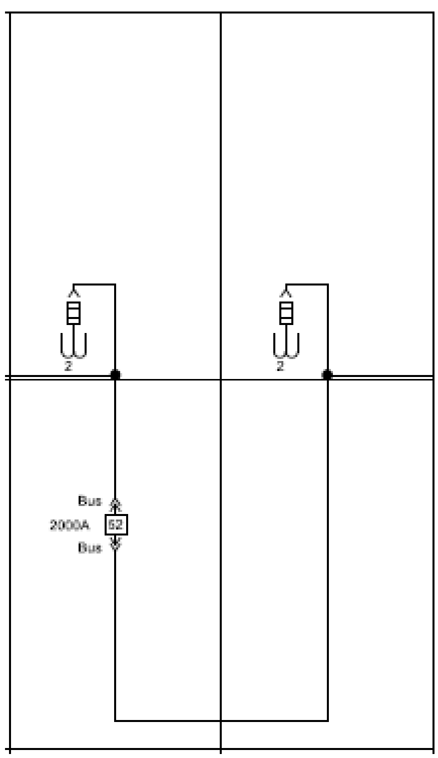
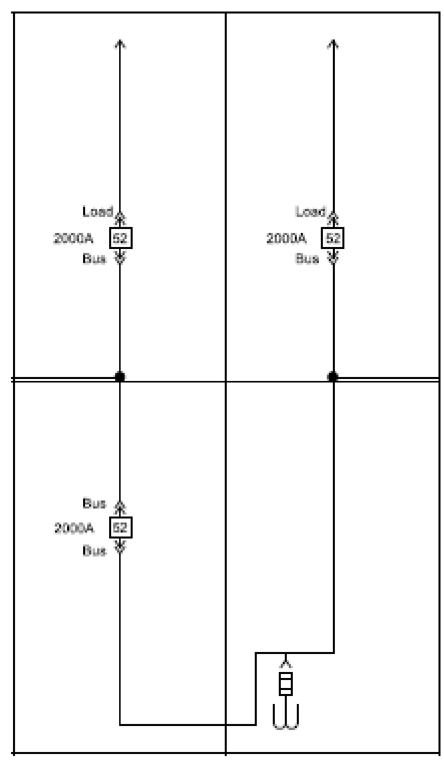


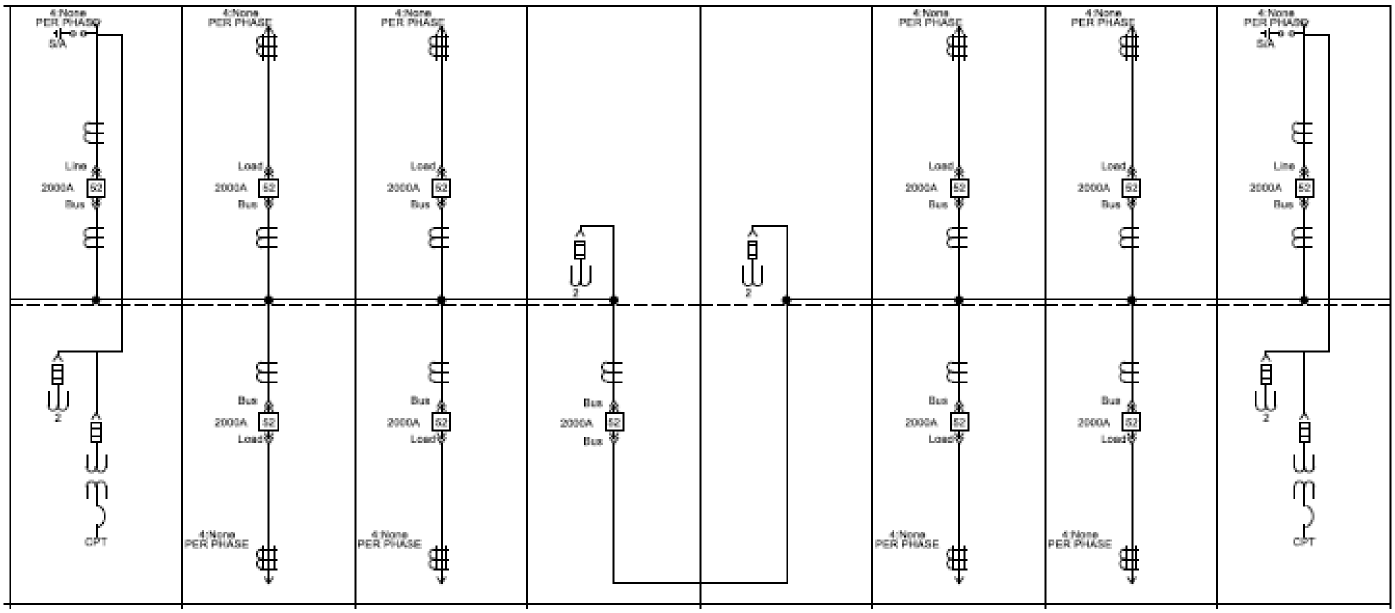
Figure 5-15: Bus VT in the Aux Tie Compartment



The lineup in Figure 5-16 shows VTs and CPTs line connected for each incoming source. Included in this arrangement are dedicated bus VTs connected on each side of the tie breaker. Each feeder breaker is shown with relaying CTs and GSCTs. The main breakers are shown with two sets of CTs and incoming surge arrestors. Incoming source connections are shown entering from above.

The main breakers can also be arranged on the ends of this main-tie-main arrangement, allowing for more options when either hot or cold sequence. Utility metering is required.

Figure 5-16: Typical Main-Tie-Main Example with Eight Feeder Breakers



SECTION 6. STANDARD SECOGEAR CONSTRUCTION, FEATURES, AND INSTALLATION

This section of the Application and Technical Guide explains the standard construction of SecoGear Metal-clad switchgear, providing details on equipment features and installation.

DOCUMENTATION

The standard support files generated by digital tools provide diagrams and general information about SecoGear Metal-clad switchgear, including

- Device summary
- Elementary diagram (power and control circuits showing each contact, coil, wire, and terminal point)
- Connection/interconnection diagram, showing physical location of devices, terminal blocks, and internal wiring
- Arrangement drawing (simple one-line diagram, front view, side views, and floor plan)

The standard documentation does not include special formatting, showing equipment other than the switchgear and direct connections.

CONSTRUCTION

Indoor Equipment

SecoGear Metal-clad switchgear is designed and constructed to meet the requirements of IEEE C37.20.2 for indoor installations with a NEMA 1 enclosure. A complete lineup of a SecoGear switchgear connects as many vertical sections as needed, splicing each section side by side with electrical and mechanical connections.

Each SecoGear vertical section can accommodate up to two circuit breakers or a combination of four VT/CPT fuse rollout trays in a self-supporting structure with a steel frame and reinforcing gussets, front and rear doors, top and side covers fabricated with 2 mm thick steel. For more information on the different stacking configurations of SecoGear, refer to Figure 1-5 through Figure 1-26.

SecoGear is equipped with grounded metal shutters in front of the primary bushings. The shutters are automatically operated by the circuit breaker movement. When the circuit breaker is racked out to the “Test” or “Disconnect” positions, the shutters automatically close to isolate the fixed primary contacts. See Figure 6-1 for shutters in closed position.

Figure 6-1: Breaker Compartment

SecoGear internal construction is designed to meet ANSI/IEEE Metal-Clad standards, using metal barriers to isolate primary compartments, such as the breaker, main bus, power termination and auxiliary compartments. The rollout trays are also furnished with 3 mm thick steel front plate that isolates the secondary control from the primary compartments.

SecoGear can be accessed through hinged doors in the front and the rear of each vertical section. Two half-height doors mounted on the front with quarter turn latches, and two on the rear with four hex-knob closing screws on each door.

Protection devices and control and instrumentation devices will be mounted on the front doors of the associated breaker compartment. Surface-mounted accessories, such as fuse blocks and terminal block will be mounted in locations within the associated breaker compartment.

Hardware

All standard assembly hardware is high tensile strength steel (SAE grade 8), which is plated to resist corrosion.

Breaker Compartments

Racking a SecoVac VB2+ circuit breaker in or out the switchgear compartment allows the breaker to roll on horizontal guide rails guiding the breaker directly to the primary contacts while continuously grounded. To operate the racking mechanism, insert the racking handle and rotate the handle clockwise until the position indicator shows the breaker in “connected” position.

To rack the breaker to the “Test/Disconnect” position, rotate the racking handle counterclockwise until the position indicator shows the breaker in the “Test” position.

An optional racking mechanism (installed in the factory, as a part of the SecoVac VB2+ breaker), can use a motor for racking the breaker in and out of the compartment. To completely remove a SecoVac VB2+ circuit breaker, you must use the provided lift truck.

> **CAUTION**
> To avoid possible damage to the racking mechanism, do not continue to turn the racking handle after the breaker has reached the “Connect” or “Disconnect/Test” position.

Figure 6-2: Ground Shoe in Breaker Cell

Visual Breaker Position Indication

The breaker compartments are provided with a visual indication for breaker position. The indicator shows whether the breaker is in the Disconnected/Test, Intermediate, or Connected position by color. See Figure 6-3, Figure 6-4, and Figure 6-5.

Figure 6-3: Breaker Position – Disconnected (Green)

Figure 6-4: Breaker Position – Intermediate (Yellow)

Figure 6-5: Breaker Position – Connected (Red)

Auxiliary Compartments

Rollout trays are provided in primary auxiliary compartments for mounting voltage transformers (VTs), control power transformers (CPTs) or CPT fuses. Two rollout trays can be accommodated in the bottom primary auxiliary compartment and two in the top compartment.

Compartment Doors

Doors can be provided with an optional door stop. Figure 6-6 shows a typical door stop for an upper compartment front door.

Figure 6-6: Door Stop and Hinges

A 3 in. IR viewing window can be added to rear compartment doors as an option. These allow for thermal and ultraviolet scanning and visual inspection. We typically provide one window per breaker.

Figure 6-7: Optional IR Viewing Window

All front doors are provided with a quarter-turn latch. Lockable handles are available as an option (Figure 6-8).

Figure 6-8: Optional Lockable T Handle

Safety Interlocks

SecoGear is designed with a number of interlocking systems to help prevent improper operation:

- The circuit breaker can be moved from “Test” to “Connect or service” position and vice versa only when the circuit breaker is in the “Open” position
- The secondary disconnect plug can be inserted or removed only when the circuit breaker is in the “Test” position
- The circuit breaker cannot be closed when it is in-between the “Connected or Service” and “Test/Disconnect” positions
- When the circuit breaker is moved from the “Connect or Service” position, the metal shutters will close automatically

Secondary Disconnect Interlocking

The secondary disconnect plug is latched in place when the breaker is racked into the connected position. Figure 6-9 shows the disconnect plug unlocked, and Figure 6-10 shows the locked position.

Figure 6-9: Disconnect Plug Not Mechanically Interlocked

Figure 6-10: Disconnect Plug Mechanically Interlocked

Safety Key Lock Provisions

SecoGear provides several provisions for installation of key locks for lock-out and tag-out procedures and safety. Front and rear doors are offered with padlock provisions as shown in Figure 6-11 and Figure 6-12.

Figure 6-11: Rear Door Padlocking Provision

Figure 6-12: Front Door Padlocking Provision

Breaker compartments are provided with padlocking to prevent unauthorized racking of circuit breakers. The racking mechanism access can be locked shut as shown in Figure 6-13.

Figure 6-13: Breaker Racking Padlock

Shutters can be padlocked in the closed position for lock-out and tag-out operations. A padlock is shown attached to the locking mechanism in Figure 6-14.

Figure 6-14: Shutter Padlocking Provision

Padlock for Open/Close Pushbutton (Optional)

A padlock for the Open/Close button will limit the access to the Open/Close button of the breaker. The Open/Close button can be operated only when the locking cover is in the open position.

Figure 6-15: Open/Close Pushbutton Locked

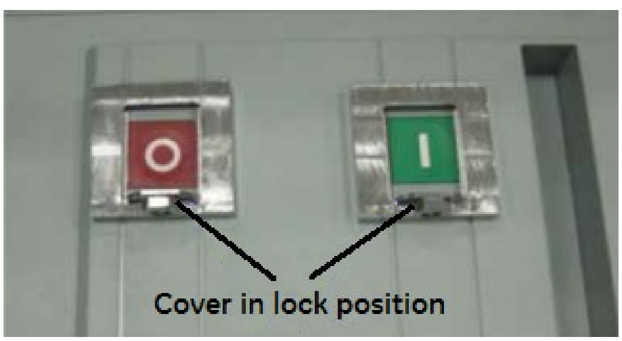
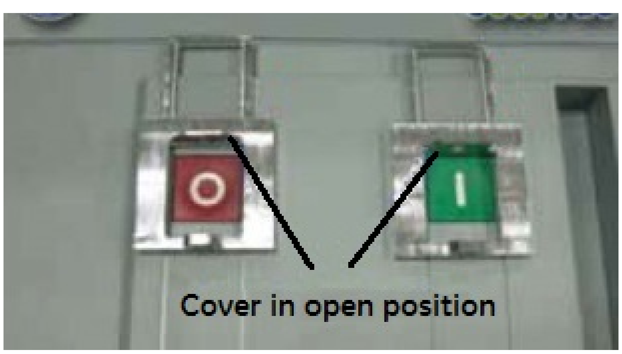


Figure 6-16: Open/Close Pushbutton Open



Main Bus

A SecoGear Metal-clad switchgear vertical section has a completely enclosed main bus, feeding the upper and lower compartments with provisions for future extensions as standard. Main bus materials are copper ASTM B187 for 1200 A and 2000 A rating (1-3/8 in. x 6 in. bar) with two 10 mm x 150 mm plated steel bolts, one bar per phase, at each bus joint.

The main bus supports have strength suitable to withstand forces caused by a 31.5 kA or 40 kA RMS symmetrical short-circuit (82 kA or 104 kA peak). The option of other materials for bus hardware and ratings is not offered.

Secondary Control

Door-mounted Devices

Protective relays, meters, instruments, controls switches, indicating lights and test blocks are typically mounted on the compartment front doors. Devices are mounted accordingly to the breaker they are associated with. If there are more devices associated with a particular breaker than the ones that can be accommodated into a breaker compartment door, the remaining devices should be mounted on the adjacent vertical section on an auxiliary compartment.

Equipment-mounted Devices

Secondary control devices that can't be mounted in the compartment door are mounted in suitable locations inside the compartment.

Ring-type current transformers, designed to meet or exceed the requirements of ANSI/IEEE C57.13, are mounted over the stationary primary disconnect bushings, accessible through the front of the breaker compartment. A maximum of four (4) CTs with standard accuracy class (ITI CT 780 & 781 for 1200/2000A) can be mounted per phase. For the optional high accuracy class CTs (ITI CT 785 & 786) only two (2) can be mounted per phase. See Table 4-2 for typical ring type CT ratios.

Figure 6-17: CT Mounting in Breaker Compartment

Figure 6-18: Typical Ring-Type CTs Mounted in SecoGear Breaker Cell

Voltage transformers and their associated fuses are mounted on rollout trays. Standard voltage transformers are ITI type PTG-5, mounted three per tray for wye connection transformers and two per tray for open-delta connected transformers.

Figure 6-19: Typical Indoor Voltage Transformer

Control power transformers can be mounted in a rollout tray up to a maximum of 15 kVA. For applications that require the use of a CPT larger than 15 kVA, SecoGear can accommodate fix-mounted CPTs up to 45 kVA single phase and 45 kVA three phase. The drawer will accommodate as many as three Class C fuses. A secondary molded case circuit breaker is key interlocked with the drawout fuse trays, to prevent withdrawing the fuses while under load.

Wiring

For standard applications, a No. 14, tinned-copper wire, rated 600 V will be used for secondary control wiring. Some applications or circuits might require a larger wire. Secondary control wires can pass around primary compartments through enclosed grounded metal troughs. Standard wire ends are furnished with crimp type, uninsulated spade terminals and sleeve type wire markers.

Power Termination Compartment

Cable termination compartments for incoming and load cables are located at the rear of the equipment and are accessible through the rear covers. Each cable termination pad can accommodate two 750 KCMIL cables per phase as standard.

As required, the power-termination compartment may be used for mounting stationary CPTs, wound-primary CTs, ground-sensor CTs, standard surge suppressors, surge arrestors, and other auxiliary devices.

Load cables for two-high breaker arrangements are isolated by a cable trough design. This provides the required isolation of each set of cables. Identification of cabling direction is critical to engineering during construction phase. See Figure 6-20 and Figure 6-21.

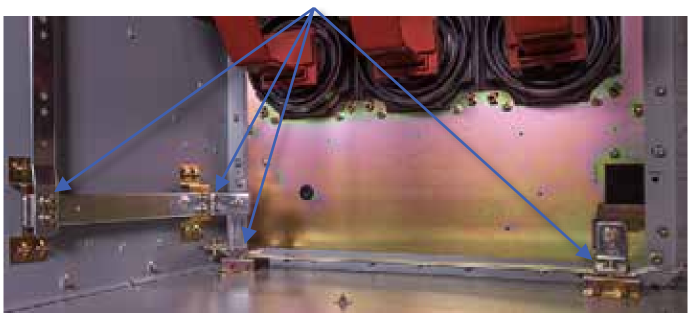
Figure 6-20: Rear View of Two high Compartment Showing Cable Trough

Figure 6-21: Cable Trough Opening

Ground Bus

The standard main ground bus bar uses 6 mm x 50 mm copper and has a short-circuit rating of 40 kA symmetrical for 2 s. The ground bus extends throughout the lineup with connections to each breaker grounding contact and each cable compartment ground terminal. All joints are made with at least two M10 plated steel bolts per joint. Station ground connection points are located in each end section.

Figure 6-22: Ground Bus Bar Bolt Locations



Equipment Heaters

Optional equipment heaters may be supplied for indoor equipment. Each heater is rated 300 W at 240 Vac but applied at half voltage (75 W for each heater element) for long life. Four heaters are mounted in each section, two front and two rear, for a total of 300 W per vertical section.

Finish and Paint

Switchgear enclosure parts are protected after pretreatment of the metal, with an electrostatically applied, baked-on polyester powder coat of Light Gray ANSI 61.

- Dry Film Thickness- Between 2.0-4.0 MILS
- 60 in-lbs direct impact resistance

Unit Nameplates

Each unit door is furnished with a nameplate specifying ratings of the section. Each nameplate is Each nameplate is 76.2 mm x 115.89 mm [3 in. x 4.56 in.], white text on medium grey background.

Accessories

Breaker Test Box

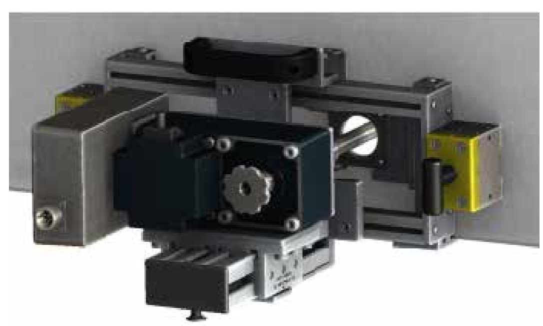
A Test Box is used to electrically operate the SecoVac VB2+ breaker when out of the breaker cell, typically at a test or repair bench. It provides a convenient means to access the breaker trip and close circuits during maintenance and inspection procedures. The Test Cabinet contains trip and close pushbuttons, on/off switch, control power fuses and a 20 ft. secondary coupler for connection to the SecoVac VB2+ breaker.

Figure 6-23: SecoVac Test Box

Breaker Racking Mechanism

An optional remote racking mechanism installed at the factory as a part of the SecoGear, can use a motor for racking the breaker in and out of the compartment. The maximum torque applied is 28 Nm during the vacuum circuit breaker racking.

Figure 6-24: Breaker Racking Mechanism



Ground and Test Device

We offer a manually operated Ground and Test Device for use in SecoGear switchgear. See SECTION 7. “Ground and Test Device” for a complete description.

Figure 6-25: Ground and Test Device

Identification of Breakers and Equipment

We provide multiple means to identify SecoVac breakers and equipment. Each breaker is provided with a label specifying ratings and identification number on the front cover. Each lineup has a metal equipment rating/identification nameplate on the front lower left hand base channel. Inside of the front cover of each breaker is a barcode label identification label. Figure 6-26, Figure 6-27, and Figure 6-28 show identification methods.

Figure 6-26: SecoVac Barcode

Figure 6-27: SecoVac Nameplate

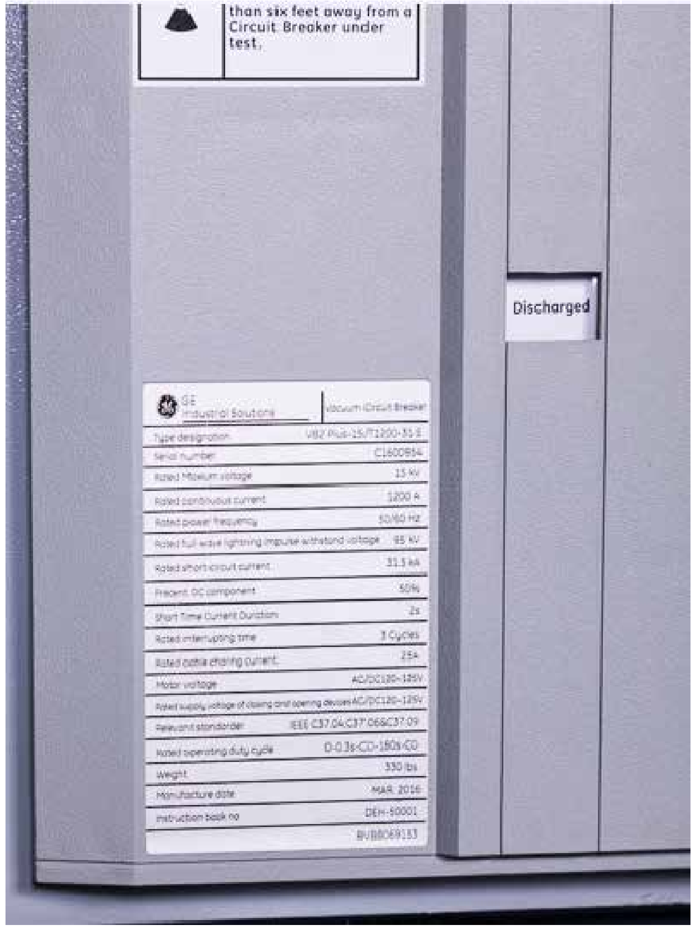


Figure 6-28: SecoGear Label

INSTALLATION INFORMATION

Typical estimating weights and dimensions are given in Table 6-1. Figure 6-29 provides typical equipment envelopes for layout and planning. Figure 6-30 through Figure 6-33 provide floor plan details showing anchor bolt locations. Power conductor and secondary conduit entrance locations are found in Figure 6-31 and Figure 6-32.

Shipping Splits

Most metal-clad switchgear lineups require many vertical sections, or stacks. These multi-section lineups are broken down into shipping splits of two stacks or less after the lineup is assembled and tested at the factory. For confined spaces at a jobsite, individual stack shipping sections are available but must be specified to engineering when ordering.

Each shipping section is bolted to wooden skids, which can be moved with a fork truck. A two stack shipping section will be approximately 118 in. deep, 100 in. high, and 88 in. wide, weighing 14,000 lbs. These shipping sections must be reassembled in the correct order when received at the job site.

Indoor Foundation Preparation

SecoGear switchgear can be mounted directly on a flat level floor; installation drawings are furnished with the equipment showing the proper way to install channel sills.

Anchoring SecoGear to the floor or channels must be properly done with a minimum of M12 (1/2 in.) Grade 5 bolts in specific locations. (See anchoring details in Figure 6-30.)

SecoGear requires a SecoVac VB2+ circuit breaker able to operate under fault conditions that cause a shock stress approximately 1-1/2 times the static load. The weight of the switchgear structure and the shock stress caused by the opening of the breakers require a strong foundation of the switchgear section. The finished floor must extend 78 in. beyond the front of the equipment, providing enough space to operate the lift truck to rack in or rack out the breakers.

The foundation must be flat (surface of pad must lie between two parallel, level planes spaced 1/8 in. apart) and level in all planes. Planes must be perpendicular to plumb line, perpendicular on both axes to within 1/4 in. across a 10 ft. span.

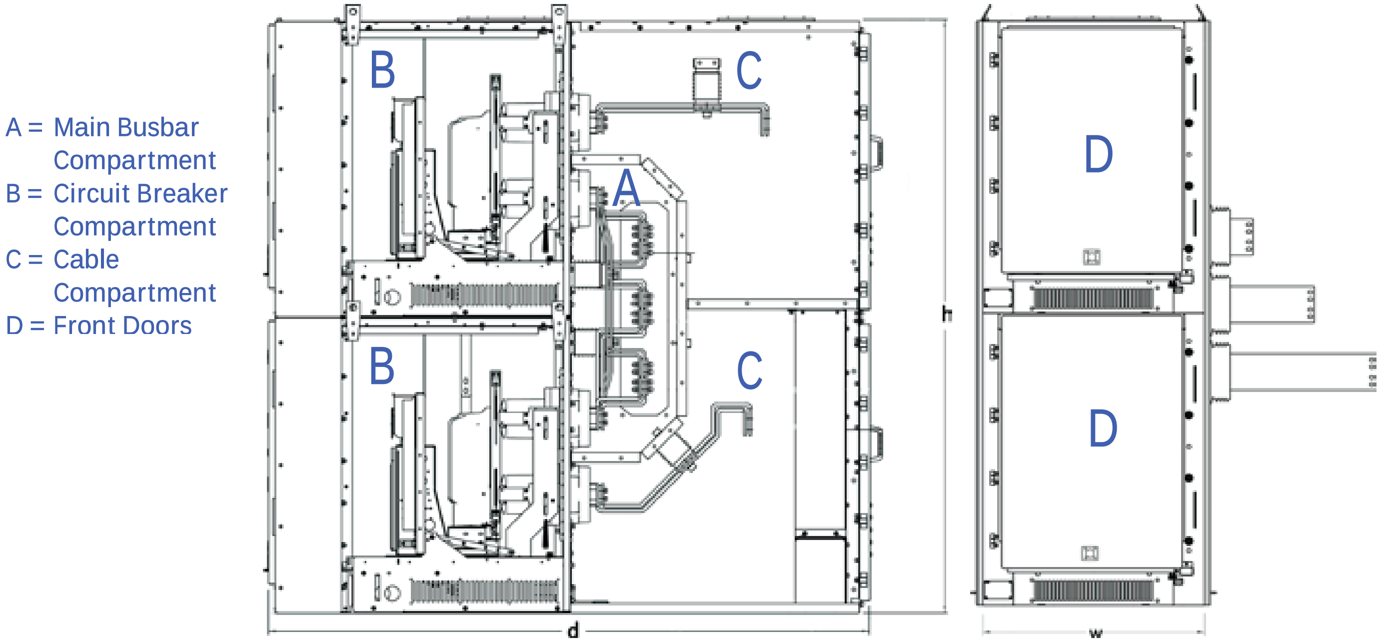
> **CAUTION**
> **It is very important to measure how far the pad is out of level and to what degree this varies over the installation. A foundation pad that is not flat and level can result in problems with breaker alignment and the racking mechanism operation, as well as placing unusual stresses on insulators and supporting structures.**

Table 6-1: SecoGear Characteristics

Specification	One-high Breaker Configuration			Two-high Breaker Configuration		
	1200/31.5 Rating	1200/40 Rating	2000/40 Rating	1200/31.5 Rating	1200/40 Rating	2000/40 Rating
Weight[1,2]	3337 lbs. [1517 kg]	3401 lbs. [1546 kg]	3803 lbs. [11729 kg]	4814 lbs. [2188 kg]	4943 lbs. [2247 kg]	5604 lbs. [2547 kg]
Height (h)	95 in. [2413 mm]					
Width (w)	36 in. [914 mm]					
Depth (d)	95.05 in [2414 mm]					

Notes:
1. If a VT rollout is provided, add 608 lbs. [276 kg].
2. If a CPT rollout is provided, add 632 lbs. [287 kg].

Figure 6-29: Section Cutaway (Height, Width, and Depth)



Anchoring Details

Refer to the SecoGear Installation, Operation and Maintenance manual (DEH-50009) for further installation instructions.

All shipping split hardware shall be disassembled before adjacent shipping packages are set in place. Reassemble to secure shipping split.

Anchor bolts, washers, and channels are to be provided by the purchaser. Recessed steel channels for supporting the equipment are recommended. However, it is allowable to mount. All dimensions shown below are for reference only.

Embedded Floor Channel Requirements

1. Each floor channel shall be level over its entire length and floor channels shall be level with each other. This is critical to prevent distortion of the equipment and to ensure proper mechanical and electrical connections between shipping splits and close-coupled equipment.
2. The finished floor shall be slightly pitched away from the mounting channels. Ensure pitch does not exceed flat and level requirements.
3. The foundation must be flat and level in all planes, perpendicular on both axes to be within 6.35 mm [0.25 in.] over a 3048 mm [10 in.] span.
4. The finished floor shall not be higher than the channels.
5. When bolting to floor channels, they must be drilled and tapped (weld nuts may be welded inside of the channels).

Maximum 25.4 mm [1.0 in.] conduit can be accommodated in this location.

Figure 6-30: SecoGear Installation Drawing – Indoor Anchoring Method

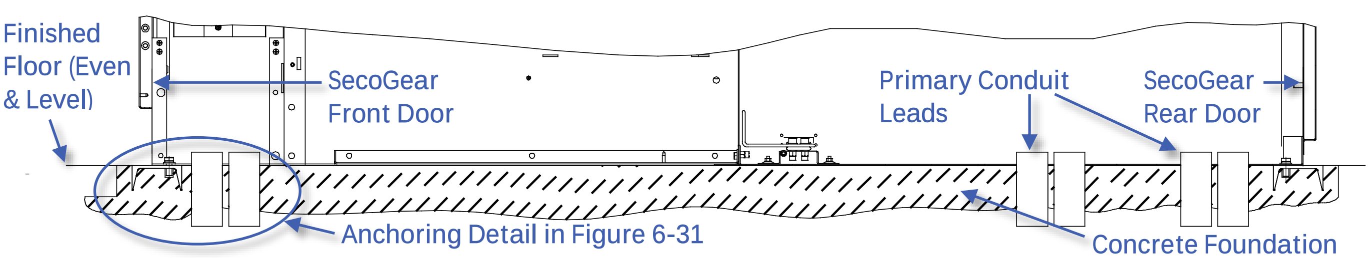


Figure 6-31: SecoGear Primary Indoor Anchoring Method

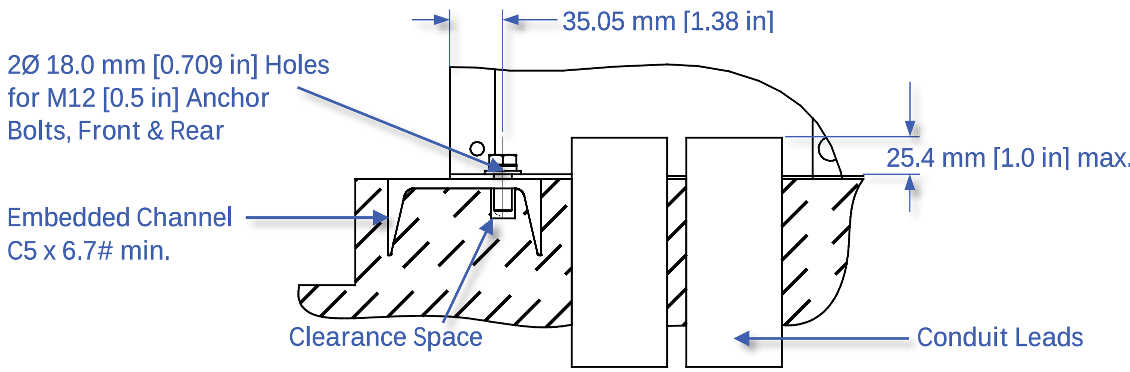


Figure 6-32: SecoGear Alternate Indoor Anchoring Method

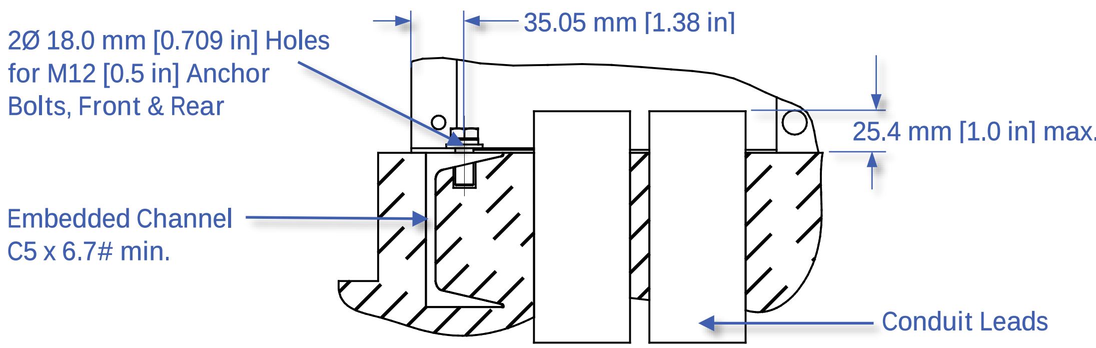
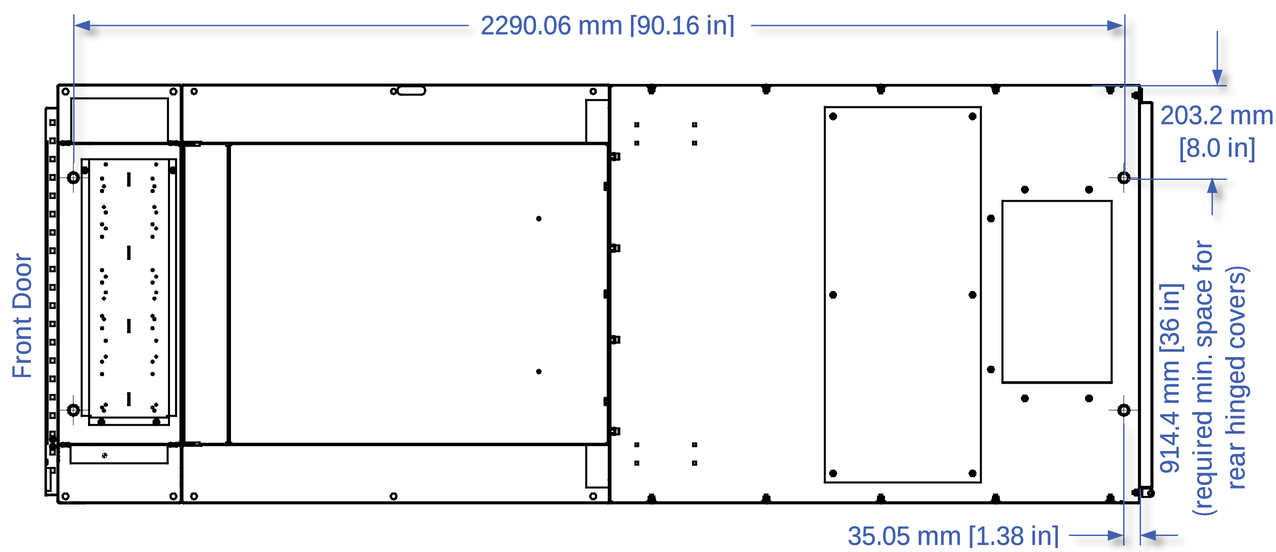


Figure 6-33: Installation Top View



SECTION 7. GROUND AND TEST DEVICE

An optional Manual Ground and Test Device, designed to meet ANSI, IEEE, and NEMA standards, is available for 1200 A or 2000 A. Consider the current rating and the short-circuit rating of the metal-clad unit when selecting a device for your equipment.

The Manual Ground and Test Device is an auxiliary removable device for use in SecoGear Metal-clad switchgear equipment during initial installation and at normal maintenance periods. The function of this device is to solidly ground the equipment manually as well as permit various types of tests.

Exposed Ground and Test Device terminals can also be used for applying high-potential tests, measuring insulation resistance to ground, and phasing out cables. The device does not have interrupters or a mechanism; therefore, it has no interrupting or closing capability.

SAFETY

The Ground and Test Device is often used during initial installation and for troubleshooting when the possibility of making an error is greatest.

The Ground and Test Device and the metal-clad switchgear have interlocks to prevent unsafe operation. Unfortunately, it is not possible to eliminate every hazard with interlocks; therefore, is the responsibility of the person using this device to recognize the potential hazards while working on potentially energized equipment and take adequate precautions.

Interlocks are provided for the safety of the operator and correct operation of the device. If an interlock does not function as described in the Ground and Test Device manual (DEH-50007), do not make any adjustment or force the device into position.

Figure 7-1: Device, Front View

Figure 7-2: Device, Contact Arms

Table 7-1: SecoVac VB2+ Vacuum Circuit Breaker Characteristics

SKU	Description	Assembly No.
SVGT10	IEEE G&T Device 1200 A/31.5 kA Manual	3PVB069044
SVGT20	IEEE G&T Device 1200 A/40 kA Manual	3PVB069045
SVGT30	IEEE G&T Device 2000 A/40 kA Manual	3PVB069046

NOTES:

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Electrification Services
305 Gregson Dr.
Cary, NC 27511 USA

For further information, please visit:
www.electrification.us.abb.com/services

For service, call:
1-888-434-7378 (US)
1-540-387-8617 (International)

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